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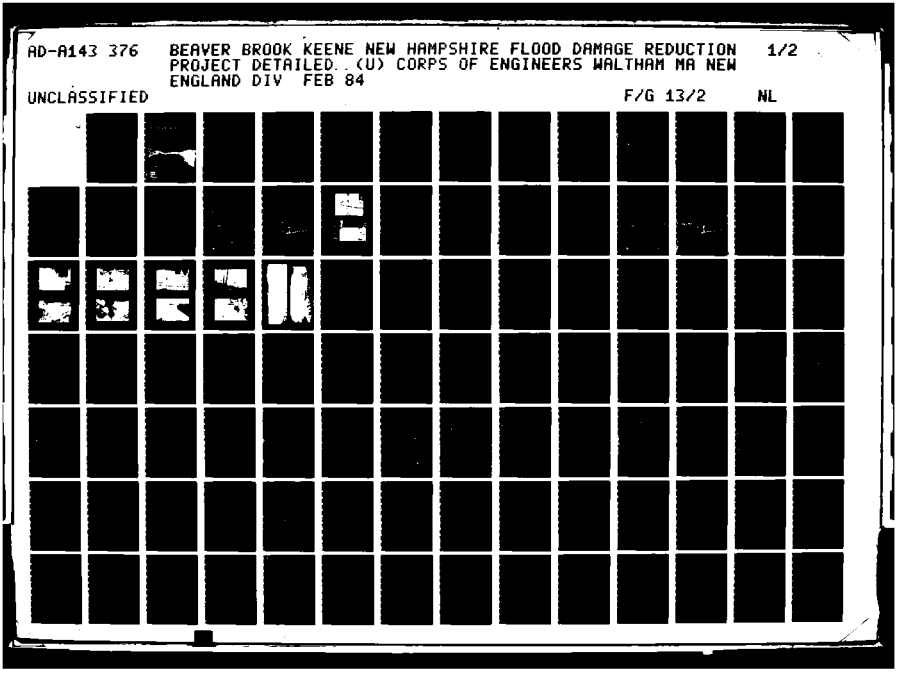

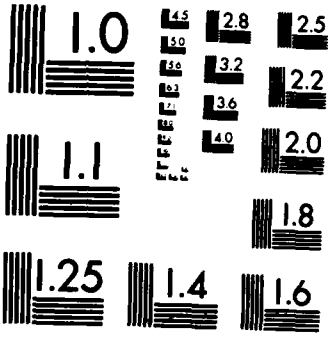


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**Detailed Project Report/ Environmental Assessment**
**Beaver Brook, Keene, New Hampshire**

# Flood Damage Reduction





FEBRUARY 1984

US Army Corps of Engineers

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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Floodways
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Channel improvements

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The report presents the results of a detailed study of flooding conditions along Beaver Brook in the eastern side of Keene New Hampshire. Frequent flooding along the brook has been a source of aggrevation to local residents and businesses, causing an average of $460,000 in damages annually. During the investigation several alternative plans of flood protection were examined for their economic and engineering feasibility. The report recommends construction of a $1.6 million plan of flood control improvements consisting of a modified outlet structure at 3 mile swamp upstream of the city, and 1700 linear ft. of channel improvements within the city limits.

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# BEAVER BROOK

# FLOOD DAMAGE REDUCTION PROJECT

# KEENE, NEW HAMPSHIRE

## DETAILED PROJECT REPORT

## FOR

## WATER RESOURCES DEVELOPMENT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254

FEBRUARY 1984

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# INTRODUCTION

This Detailed Project Report presents the results of an investigation of flooding conditions occurring along Beaver Brook in Keene, New Hampshire, and recommends construction of a selected plan of improvements to reduce the damaging effects of these floods.

Keene is located in the valley of the Ashuelot River, at the point where three tributaries converge on the valley floor. With limited developable land available outside the floodplain, Keene has experienced flooding problems since the earliest times. Although the city has prepared a comprehensive plan that acknowledges continued flooding in its vision for the future, a plan of action should be adopted to assist those citizens currently suffering from flood losses.

## STUDY AUTHORITY

This report was prepared under the special continuing authority of Section 205 of the 1948 Flood Control Act, as amended, which states: "The Secretary of the Army is authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $30,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which come within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the Chief of Engineers such work is advisable. The amount allotted for a project shall be sufficient to complete Federal participation in the project. Not more than $4,000,000 shall be allotted under this section for a project at any single locality. The provisions of local cooperation specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvement to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submissions of preliminary examination and survey reports."

Federal assistance in providing local flood protection was requested by the Keene City Manager by letter dated November 24, 1980. Authorization for the preparation of this Detailed Project Report was provided by the Office of the Chief of Engineers on March 26, 1981.

## STUDY AREA

This investigation specifically addresses the flooding problems of eastern Keene resulting from Beaver Brook, a tributary of the Ashuelot River. A watershed map of the Ashuelot River is shown on Plate 1. The selection of Beaver Brook as the focal point of this investigation was based on the following reasons:

First, previous investigations of the flood problems in Keene established that 93 percent of total average annual flood damages in Keene occur in the Beaver Brook floodplain.

Second, the same investigations identified Beaver Brook as the most likely location where small structural flood control measures could be feasible.

In total the Beaver Brook flood plain inundates approximately 442 residential, commercial and industrial structures during the Standard Project Flood(1). For the purposes of this study, the Beaver Brook flood plain was divided into six reaches, numbered 0 through 5.

Reach 0 extends from the mouth of Beaver Brook up to the Route 101 overpass and includes mostly commercial and residential property.

Reach 1 extends about 2,400 feet upstream from the bypass to Marlboro Street and is characterized by single family dwellings with some strip commercial development along Marlboro Street.

Reach 2, extending from Marlboro Street up to the Boston and Maine Railroad Bridge, includes the largest industrial complex of the flood plain, that of the Kingsbury Machine Tool Company. Also included in this reach of the flood plain are residential and commercial properties located on the west side of the brook.

Reach 3 extends from the railroad bridge upstream about 1,700 feet to Roxbury Street and includes a mixture of commercial, industrial and residential property, as well as some vacant land. This reach contains some of Keene's oldest industrial development, including the Princess Shoe Building, formerly a large manufacturing concern that now houses small retail and industrial firms.

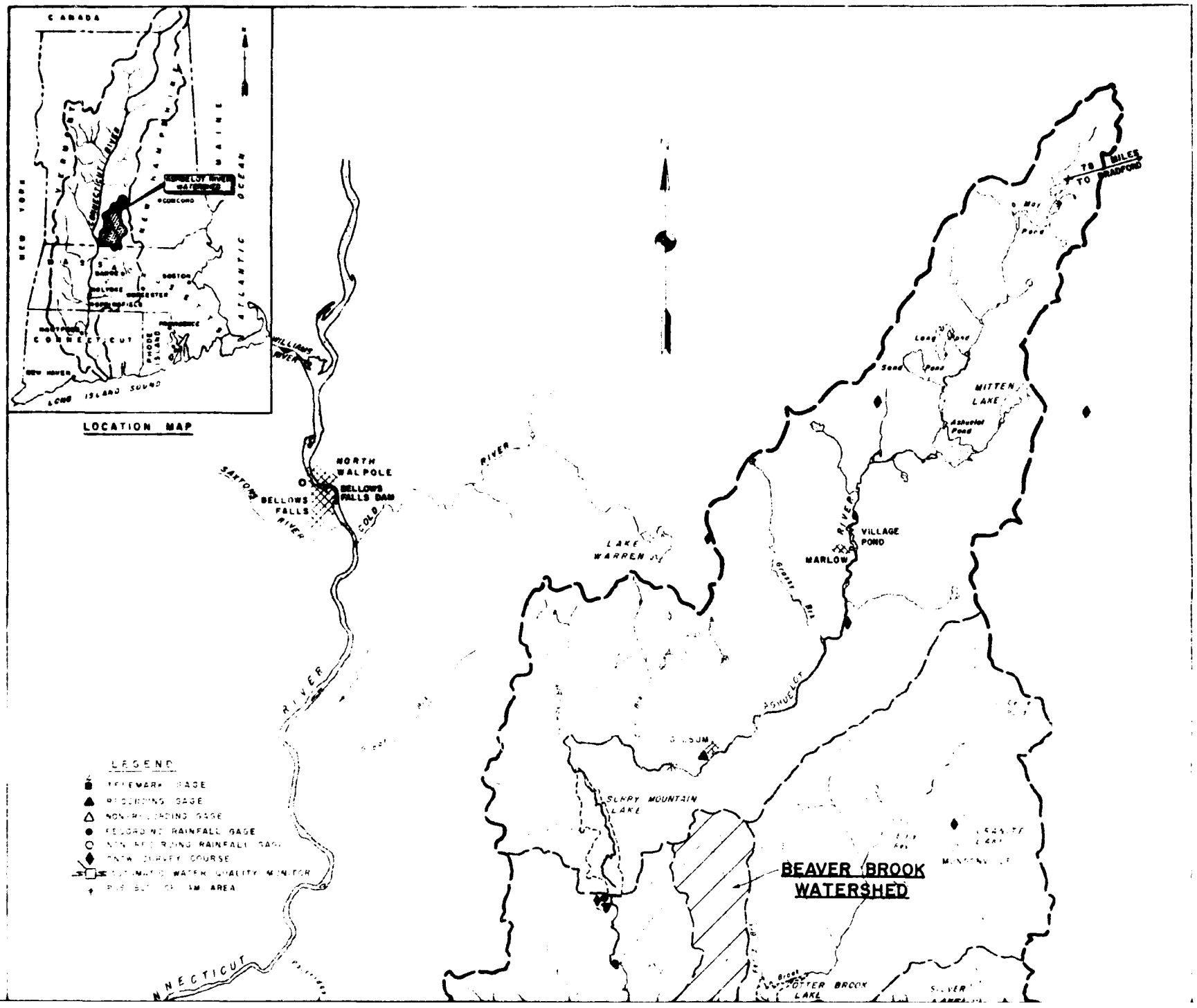
Reach 4 extends from Roxbury Street to Beaver Street and includes a mixture of large single and multi-family homes located on smaller lots.

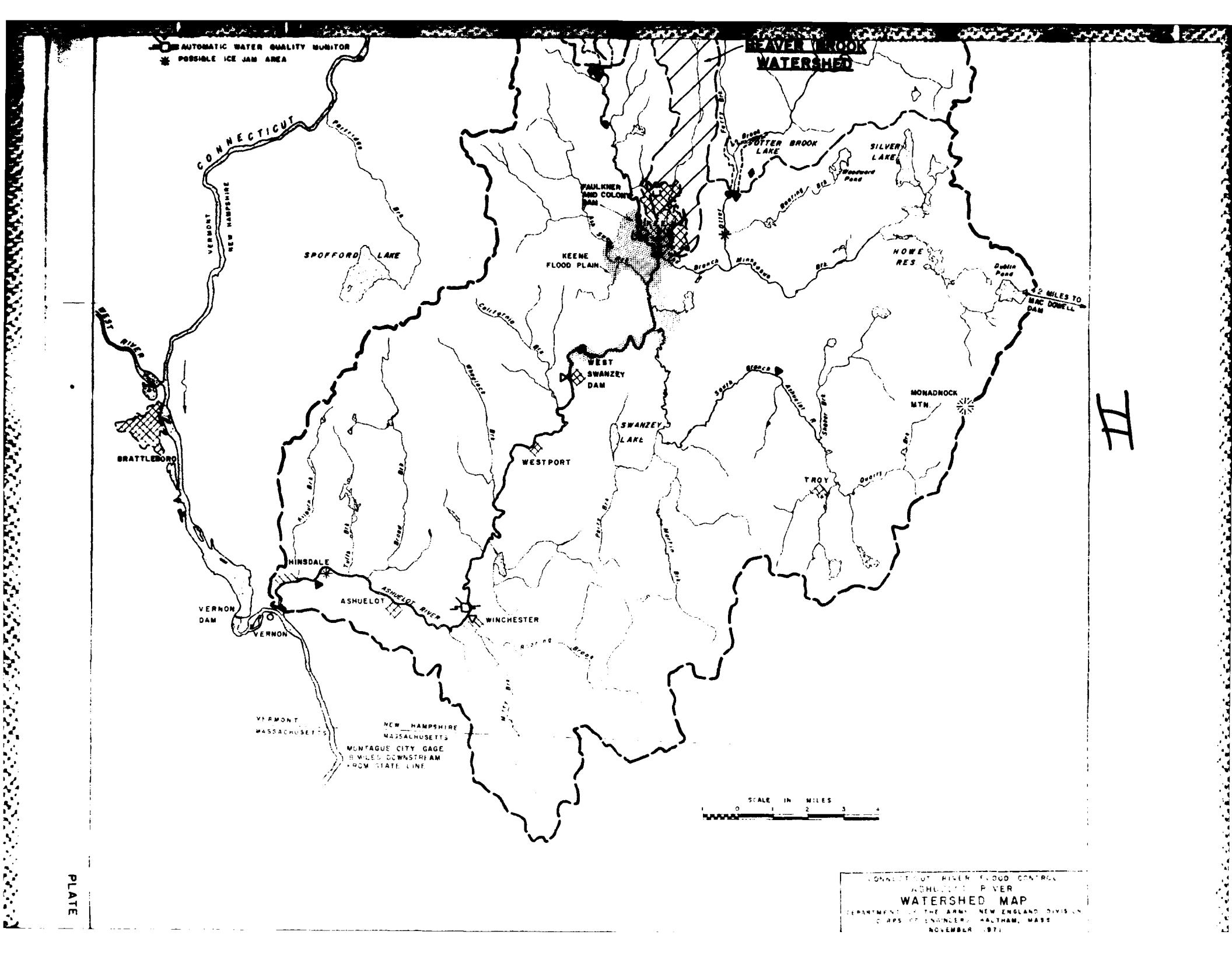
Reach 5 extends from Beaver Street upstream about 4,000 feet to the upper limit of the urban flood plain around Giffin Street. Although most of the land in this reach is occupied by the Woodland Cemetery, there are some residential and commercial structures located north of the cemetery that are susceptible to flood damages.

## STUDY OBJECTIVE AND SCOPE

This investigation was initiated at the request of the Keene City Manager after a previous Congressionally authorized study, entitled Formulation, Assessment and Evaluation of Non-Structural Flood Damage Reduction Techniques, Keene, N.H. (May 1980), concluded that flood control within

(1) The Standard Project Flood (SPF) is defined as the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the region, excluding extremely rare combinations.


CANADA
CONNECTICUT RIVER
CONNECTICUT RIVER WATERSHED
CONCORD
BOSTON
PROVIDENCE
NEW HAVEN
LONG ISLAND SOUND
ATLANTIC OCEAN
MAINE
NEW YORK
LOCATION MAP
WILLIAMS RIVER
NORTH WALPOLE
BELLOWS FALLS DAM
BELLOWS FALLS
SAXTONS RIVER
COLD
LAKE WARREN
VILLAGE POND
MARLOW
ASHUELOT
MITTEN LAKE
Long Pond
Sand Pond
Ashuelot Pond
TO 5 MILES TO BRADFORD
SUNAPEE
SUNAPEE LAKE
SLEEPY MOUNTAIN LAKE
BEAVER BROOK WATERSHED
OTTER BROOK LAKE
SILVER LAKE
LEGEND
TELEMARK GAGE
RECORDING GAGE
NON-RECORDING GAGE
RECORDING RAINFALL GAGE
NON-RECORDING RAINFALL GAGE
SNOW SURVEY COURSE
AUTOMATIC WATER QUALITY MONITOR
DIRECTION OF SAM AREA




CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION
CORPS OF ENGINEERS WALTHAM, MASS
NOVEMBER 1971

PLATE II

the Beaver Brook watershed could be better accomplished under the continuing authority of Section 205. Under Section 205 the Detailed Project Report serves as an authorizing document for construction of a local protection project. Upon approval of the report by the Chief of Engineers, plans and specifications for construction of the proposed project are prepared.

The previous study, conducted under the authority of a United States Senate Resolution of 11 May 1962, and guided by the policies of Section 73 of Public Law 93-251, was primarily directed toward reducing flood damages by nonstructural measures. However, that study concluded that the widespread application of nonstructural measures was not feasible for Keene, but recommended that small-scale structural measures be used to provide low-level protection along Beaver Brook.

Although the concept of low-level protection deviates from the Corps of Engineers' policy for flood protection in urban areas, this Section 205 study represents another in a series of attempts to provide some form of flood relief to the residents of the Beaver Brook flood plain. The concept of small-scale structural works was approved by the Chief of Engineers at the conclusion of the Section 73 investigation when a Memorandum For Record, summarizing the Section 73 study recommendations, received a first indorsement dated 21 August 1980.

Because this Section 205 investigation is founded upon the conclusions of the Section 73 nonstructural investigation, much of the information presented in this report was developed during that study. However, a Detailed Project Report is meant to provide enough design detail on the selected plan of improvements to enable preparation of plans and specifications directly upon approval of the report. Therefore, the focus of this study has been towards refining available hydrologic and economic data on the Beaver Brook flood plain, and collecting enough information on topographic and geotechnical conditions to develop detailed design drawings and cost estimates for the alternative plans.

The economic analysis required an update of the damage surveys accomplished during the Section 73 investigation, including extending these figures to reflect potential losses from the Standard Project Flood (the former study only considered flood losses up to the 100-year event). Using stage-frequency curves developed in the hydrologic studies, the economic damages have been correlated to floods of varying magnitude to assess the full range of damages likely to be experienced along Beaver Brook. This information provided the basis for a benefit analysis of each proposed alternative.

The study also examined the environmental and social characteristics of the Beaver Brook flood plain to enable due consideration of these factors in the development of a local flood protection plan.

## PRIOR REPORTS

Flood control for the city of Keene has been the subject of numerous reports prepared over the last four decades by the Corps of Engineers and others. A listing of reports pertaining to Beaver Brook, and a summary of their recommendations, follows:

In 1962, under contract to the city of Keene, Camp Dresser and McKee produced their Report on Drainage in the Beaver Brook Area, which addressed the interior drainage system of the lower Beaver Brook watershed. The report assumed that an upstream flood control dam, under study at that time by the Corps of Engineers, would eventually be constructed. The report recommended construction of several measures, including a pumping station, to increase the capacity of the existing gravity drainage system. None of these recommendations has yet been constructed, however, as the city has since concentrated on other ways of reducing Beaver Brook's flood problem. It should also be noted that the 1980-1984 Capitol Improvements Program does include some improvements in the local drainage system.

The Corps of Engineers' involvement in flood control along Beaver Brook began with a Senate Resolution of October 3, 1960. In 1963, the Corps of Engineers prepared the Reconnaissance Report, Beaver Brook, New Hampshire, recommending further investigation of the feasibility of constructing a flood control reservoir within the Beaver Brook watershed.

Subsequent to the above report, the Corps produced a Draft Supplementary Reconnaissance Report, Beaver Brook Dam and Reservoir, dated March 1964. This report presented detailed cost allocation studies for the development of a multiple-purpose dam and reservoir on Beaver Brook, to be constructed in one or two stages. Upon review of the Draft, the Chief of Engineers recommended construction of a single stage multiple-purpose reservoir, and allocated funds for a detailed study. However, in April 1965, the Keene City Council passed a resolution in favor of the two-stage dam project, citing that the city did not have an immediate need for the water supply provided by the dam. Furthermore, the interim waterbased recreation to be generated by the single stage construction of the dam was viewed by the city as unnecessary because of existing facilities at the Surry Mountain and Otter Brook Reservoirs.

In July 1965, the Corps' studies produced the Interim Report on Review of Survey, Beaver Brook Dam and Reservoir, recommending construction of a multiple-purpose dam and reservoir on Beaver Brook, to include flood control, recreation, fish and wildlife conservation, and provisions for future water supply. Storage allocated to flood control amounted to 2,750 acre-feet, equivalent to 8.6 inches of runoff from the upstream drainage area of 6 square miles. A major element of the plan involved the relocation of approximately 2.0 miles of New Hampshire Route 10, which runs parallel to Beaver Brook. The proposed dam would have had sufficient capacity to store upstream runoff from the Standard Project Flood, and from a recurrence of the September 1938 flood of record. During moderate floods it would have reduced downstream stages in the Roxbury-Beaver Street area by two to three feet.

Upon review of the July 1965 report, the Board of Engineers for Rivers and Harbors concluded that the proposed dam provided local flood protection for Keene only, and returned the report to the New England Division for a revised plan of cost sharing with non-Federal interests. In December 1966, a revised report, reflecting further coordination with local officials on the issue of cost sharing, was submitted to Washington for final approval. This revised submission contained substantial changes in the non-Federal share of financing for the project, requiring an initial investment by the city of $713,000, instead of $265,000 proposed in the original submission. The Beaver Brook Lake Project was authorized by Congress by the 1968 Flood Control Act. However, due to escalated non-Federal costs, local assurances could not be obtained from the city of Keene and the project was subsequently deauthorized on 18 April 1978.

In the interim period, the city of Keene went back to Camp Dresser and McKee (CDM) to request a study of channel conditions along the Beaver Brook. Prepared in December 1967, the Report on Channel Improvements for Beaver Brook from Beaver Street to Baker Street recommended a complete plan of channel and bridge improvements for Beaver Brook assuming that the upstream dam would be constructed. Of the recommended actions, only a concrete channel lining from Harrison Street to Spring Street was constructed. Later on in 1974, however, after the city had abandoned their efforts on the Beaver Brook Dam, CDM was requested to update their report on channel improvements to reflect flooding conditions without the dam. This revised letter-report recommended that the entire Beaver Brook channel downstream of Harrison Street be cleared of debris, and that new bridges or extra culverts be constructed at Myrtle Street, the Boston and Maine Railroad crossings and at Water Street. The report estimated that these improvements would increase the channel capacity enough to reduce experienced 1973 flood stages by 2 to 3 feet.

In May 1975, the consulting firm of Whitman and Howard, Inc. prepared a report entitled Beaver Brook Improvements: Harrison Street to Baker Street. This report outlined a three-phase plan of capital improvements designed to increase the Beaver Brook channel capacity from 400 to 750-850 cubic feet per second. The report provided cost estimates for the proposed work but did not attempt to assess the economic feasibility of the recommended improvements. Phase I of the plan called for dredging a trapezoidal channel downstream of Baker Street, replacing the bridges at Baker and Marlboro Streets, replacing the Kingsbury Machine Tool Company's (KMT) footbridge, and channel improvements just downstream of the KMT footbridge. With the exception of replacing the footbridge, all of the above items were accomplished.

Phase II called for improvements in the reach of Beaver Brook between the KMT footbridge and Harrison Street, including a concrete channel and replacement of several bridges. None of these recommendations has yet been implemented.

Phase III called for channel dredging and widening in the reach upstream of Marlboro Street and between Water Street and Harrison Street, with construction of a concrete retaining wall in the bend of the channel just downstream of Harrison Street. Although this phase has not been fully implemented, some of these recommendations are reflected in channel clearing accomplished by the city during reconstruction of the Marlboro Street bridge, and in the bank stabilization work constructed behind KMT.

Later in 1975 the Keene City Planning Board, with the assistance of Hans Klunder Associates, Inc., prepared the Keene Comprehensive Plan to guide the future growth of the city. The Comprehensive Plan addresses Keene's future in terms of open space, education, the central business district, housing, transportation and land use. The plan, in part, calls for the acquisition of seasonal flood plain lands for preservation as open space. However, recognizing that considerable pressure exists to develop the low lands, the Keene plan also provides for the development of industry within the flood plain. Of all the forms of development possible, this is viewed by the city as most in need of inexpensive land, and most adaptable to the requirements of flood plain development.

Two final reports that address the flooding problems of Keene were prepared for or by the Corps of Engineers under the authority of the U.S. Senate Resolution adopted 11 May 1962. These reports were prepared in connection with a pilot study of the feasibility of implementing the policies of Section 73 of PL 93-251 (nonstructural flood control improvements) in the Connecticut River Basin. The first, Formulation, Assessment and Evaluation of Nonstructural Flood Damage Reduction Techniques - Keene, New Hampshire, was prepared by Camp Dresser McKee/Resource Analysis in May 1980, under contract to the New England Division Corps of Engineers. The report provides the results of a comprehensive study of flooding conditions in Keene and recommends a general flood plain management program for the entire city. Although the program concentrates on nonstructural measures of flood damage reduction, the report recommended that several small-scale structural measures be considered for implementation along Beaver Brook.

The second report, Connecticut River Basin - Feasibility Study of Nonstructural Flood Damage Reduction Measures, was prepared by the New England Division in January 1981. This report basically summarized, through stage II, the results of nonstructural investigations carried out for each of the three communities included in the pilot study. The report, therefore, draws from the CDM/Resource Analysis study for its discussion of Keene, and contains the same recommendations for Keene as did that report. With regard to Beaver Brook, these basically were that a lined concrete channel in one reach of Beaver Brook, combined with the modification of the Three Mile Swamp control structure to increase upstream storage, and construction of small walls and levees in other areas could together alleviate some of the flooding problems on Beaver Brook. The report also recommended that a plan of floodproofing, floodwarning and flood plain zoning be adopted by the city to minimize future flood losses.

## EXISTING PROJECTS

The U.S. Army Corps of Engineers operates two flood control reservoirs upstream of the city of Keene. Surry Mountain Dam located on the Ashuelot River, was completed in 1941 and Otter Brook Dam, located on Otter Brook (a tributary of the Branch), was completed in 1958. These dams, which combine to control approximately 150 square miles of drainage area upstream of Keene, are an integral part of a larger flood control system designed to protect the greater Connecticut River Valley. Within Keene itself, they represent the greatest effort to date to control the flooding problems of the city.

On Beaver Brook, efforts to control flooding have been limited to a phased sequence of channel improvements accomplished by the city and private industry at several locations along the Brook. These include bridge replacements at Baker and Marlboro Streets, channel clearing and widening from the Route 12 overpass to Baker Street, riprap channel work in the location of the Kingsbury Machine Tool Company, and the concrete-lined channel improvements between Harrison Street and Spring Street. Plate 2 contains a map of eastern Keene showing the various reaches along Beaver Brook where channel improvements have been accomplished.

## BACKGROUND INFORMATION

### General

Keene is located in southwestern New Hampshire approximately 15 miles north of the Massachusetts border and 12 miles east of the Vermont border. It has a population of 21,400 and is home to Keene State College as well as the Cheshire County seat. Situated in the flood plain of the Ashuelot River, Keene first developed around the timber industry, which relied upon the rivers to power its saw mills. Today the city has evolved into a center of commerce and industry for the western half of the State, serving a regional population of 100,000.

The city of Keene has a total land area of 23,680 acres distributed over the mountains and valleys that comprise the Ashuelot River system. The main stem of the Ashuelot River flows from north to south through the city of Keene, dividing it in nearly equal parts. On each side of the valley large foothills rise steeply up from the floodplain. Draining these hills are the Branch and Beaver Brook on the east, and the Ash Swamp Brook on the west.

Although Keene's development today spans to the foothills around the city, the majority of commerce and industry is still concentrated in the flat lands of the flood plain, where manufacturing first developed. By consequence some of Keene's oldest and most densely populated neighborhoods are located in the flood plain, most notably along Beaver Brook. Although recent expansion has claimed some of the foothills around the city for residential purposes, the future development of these uplands is limited by public policy and by the physical characteristics of the land. Public policy dictates that water and sewerage service will only be provided up to elevation 620 feet NGVD[1] because this is the limit of the existing service and a great capital expense would be required to expand this system. The steep terrain and thin topsoils characteristic of the surrounding hillsides make development difficult and costly in the absence of these services. Thus it is that the Keene flood plain will continue to experience the pressures of future growth. In planning for the future, the city of Keene has carefully weighed the costs of upland development against the potential losses that could result from development of the flood plain.

In total, the 100-year flood plain extends over 1,400 acres of Keene's land. By 1979, over one quarter of this flood plain land (384 acres) had been developed for residential, commercial and industrial use, and another 446 acres was either in agricultural use, or had been acquired for conservation/open space purposes. In the eastern section of Keene, where Beaver Brook flows south through older residential and industrial

[1] NGVD (National Geodetic Vertical Datum) is defined as Mean Sea Level of 1929.

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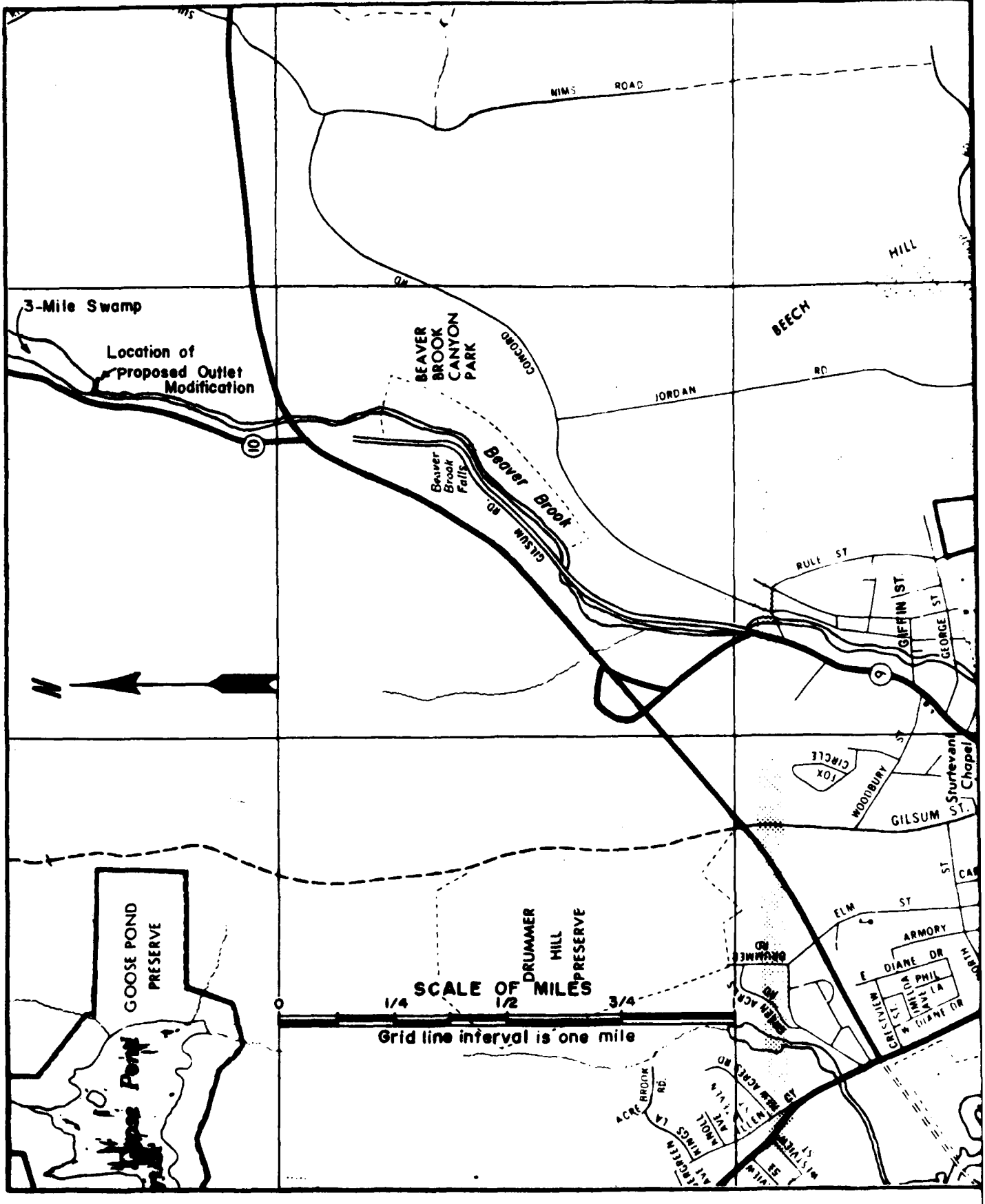
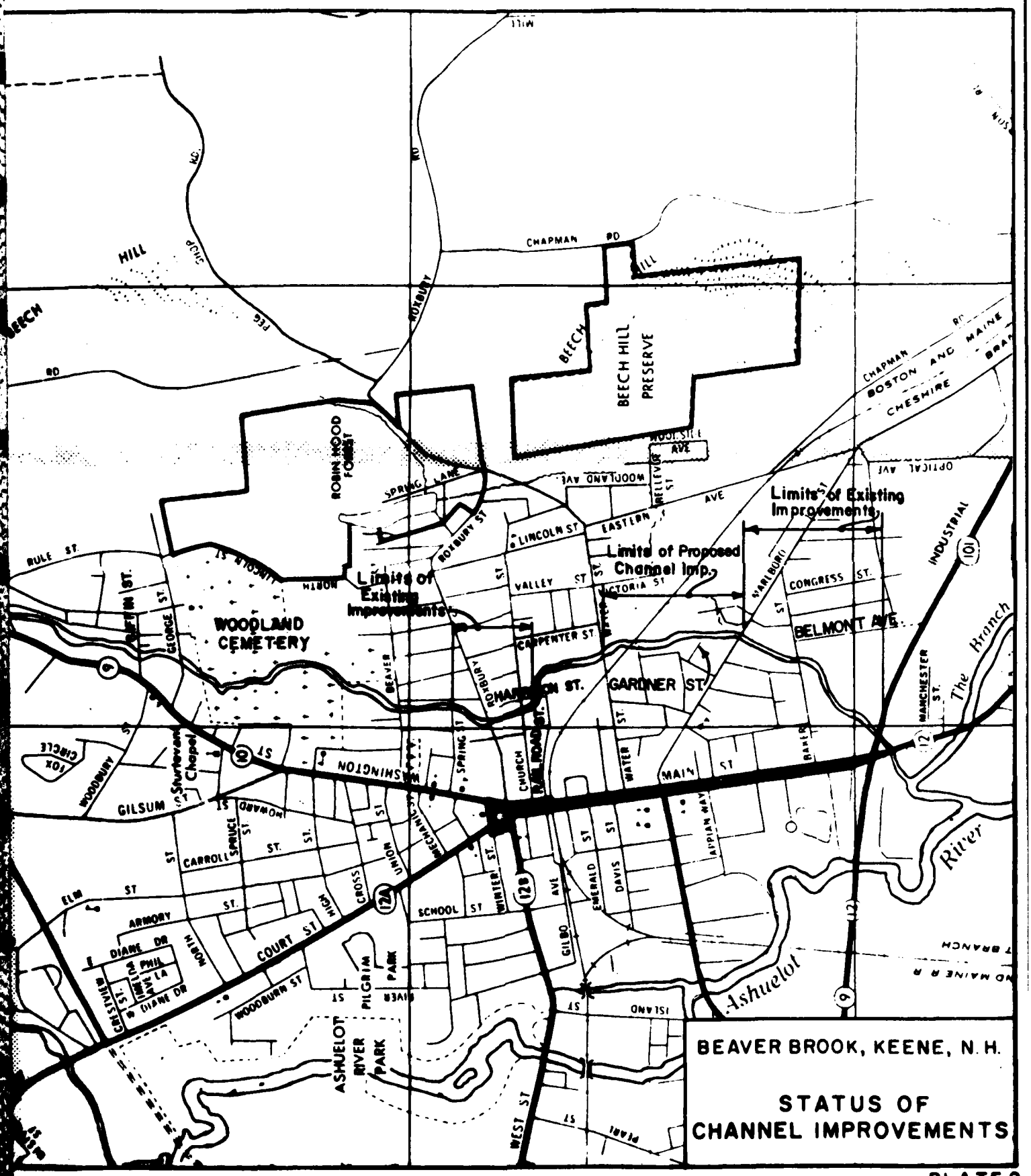

3-Mile Swamp
Location of Proposed Outlet Modification
BEAVER BROOK CANYON PARK
Beaver Brook Falls
Beaver Brook
MIMS ROAD
HILL
BEECH
JORDAN RD
GILSUM
RULE ST
GRIFFIN ST.
GEORGE ST
WOODBURY
FOX CIRCLE
GILSUM ST.
Sturtevant Chapel
ELM ST
ARMORY
E DIANE DR
PHIL
IMELDA LA
DIANE DR
CRESTVIEW CT
ACRE BROOK RD.
GOOSE POND PRESERVE
DRUMMER HILL PRESERVE
SCALE OF MILES
0
1/4
1/2
3/4
Grid line interval is one mile

II




BEAVER BROOK, KEENE, N.H.

STATUS OF CHANNEL IMPROVEMENTS

PLATE 2

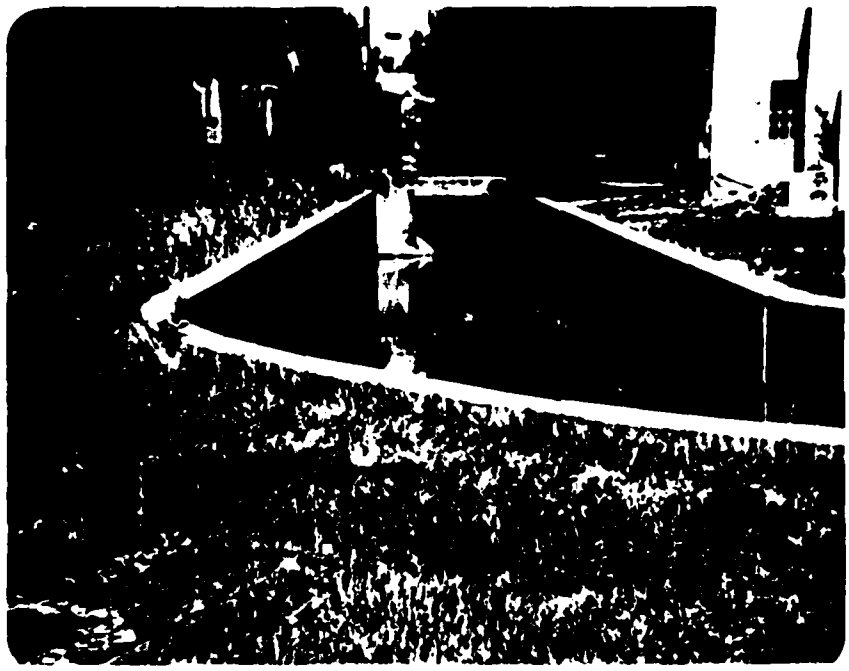
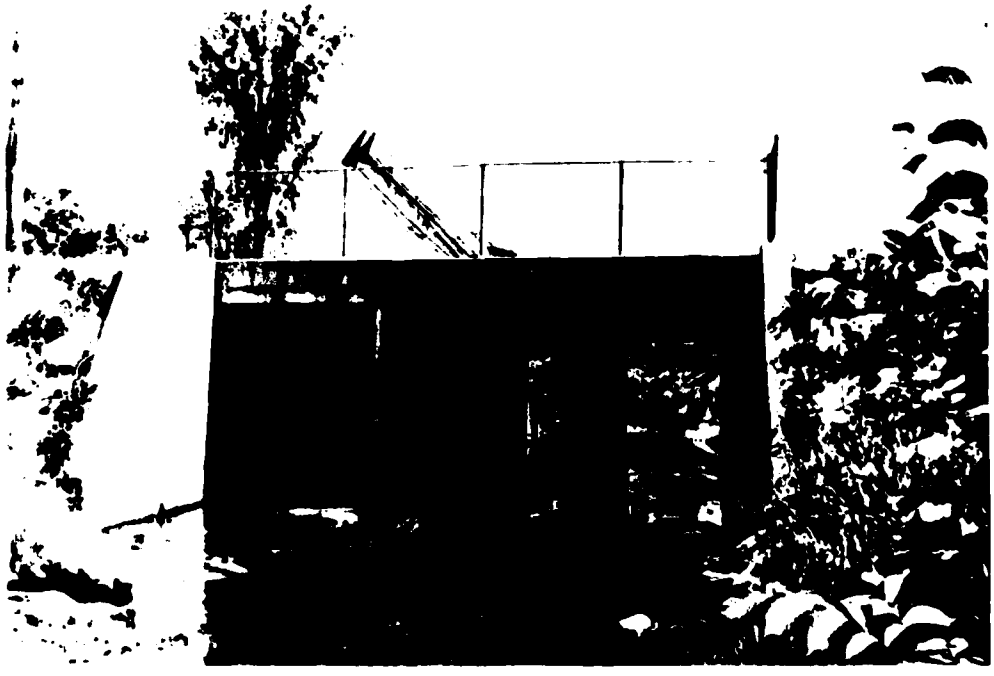


Photo Courtesy of P. Bourassa, Jr.



Existing Improvements along Beaver Brook

TOP: Channel lining between Spring Street and Harrison Street looking upstream toward Church Street

BOTTOM: Looking upstream at Marlboro Street Bridge

quarters, virtually all of the flood plain lands have been claimed for development. It is in this area where the city's flood problems are most critical, and upon which this investigation is focused.

## Basin Description

Beaver Brook drains an area of about 10 square miles located east of the Ashuelot River and almost entirely within the limits of the city of Keene. The watershed is rectangular in shape, running north to south a distance of about 7 miles and having a maximum width of 1.5 miles. It is characterized by a single stream pattern with numerous short, steep tributaries that run perpendicular to the brook, draining the surrounding hillsides. Although Beaver Brook falls a total of 700 feet in its 8 mile course, most of this drop occurs in the upper limits of the watershed and again just before the river emerges on the valley floor at George Street.

In the intervening reach the river profile flattens and Beaver Brook flows into a large swamp, known as the Three Mile Swamp. A small earth and stone dam approximately 190 feet long and 3.5 to 4 feet high is responsible for the creation of the swamp, which currently has a fairly stable pool elevation at 787 feet NGVD. During periods of rainfall and snowmelt the pool elevation of the swamp rises slightly while it stores runoff from the upper basin, but most of the floodwaters are discharged directly over the low dam.

In the lower reaches of the basin, having fallen over 300 feet in elevation from the outlet of the swamp, Beaver Brook enters the urbanized area of its watershed, in the greater flood plain of the Ashuelot River. Here the Beaver Brook flood plain contains a mixture of medium to high density residential property, as well as mixed commercial and industrial development. Because the gradient of the brook is very flat in this reach, river stages are influenced by flood levels on the Ashuelot River, and the flood plain spans a broad area.

All told, the rugged terrain of the upper Beaver Brook watershed, with its steep tributaries and single stream pattern, makes Beaver Brook a hydrologically flashy stream, quick to pour its runoff into the valley below. Once there the floodwaters are stilled by the lack of gradient, and they spill over the banks of the river and into the flood plain, where they are stored until downstream waters recede.

## Climatology

Keene has a variable climate characterized by frequent but generally short periods of heavy precipitation. Some intense rainfalls are produced by local thunderstorms while others result from larger weather systems travelling up the eastern seaboard. New Hampshire also lies within the path of the prevailing westerlies which travel across the continent in an easterly or northeasterly direction. These weather patterns are responsible for the rapid and extreme changes in temperature which occur so frequently in New England.

Winters in Keene are moderately severe with low temperatures averaging around 20 degrees Fahrenheit in January and extreme low temperatures experienced in the minus thirties. Snowmelt usually occurs in late March or April, although mid-winter thaws have occurred. Summer temperatures in New Hampshire are cool to moderate, averaging 70 degrees in July and ranging to as high as 100 degrees. The average annual temperature, based on 94 years of record, is 46 degrees.

Precipitation over the Keene area has averaged 38.9 inches annually over an 89-year period of record. Distribution of this precipitation is fairly even throughout the year with snowfall occurring from November through March. The greatest annual precipitation on record was 52.7 inches occurring in 1975, and the least was 27.1 inches in 1894. The maximum monthly precipitation on record was 11.09 inches occurring during the month of July, indicating that floodflows are equally likely in summer as they are in the spring thaw. Snowfall averages 64.3 inches annually. During the winter months, the water equivalence of the snow cover rises to a maximum in mid-March, when it averages 4.7 inches. However, the greatest water equivalence of snow cover on record was 9.6 inches, recorded early March, 1969.

## Streamflow

Streamflows on Beaver Brook are unrecorded and, therefore, have been estimated based on data available from similar watersheds. The two nearest gages recording runoff from watersheds similar to Beaver Brook are on the South Branch Ashuelot River in Troy, New Hampshire, and on the Ashuelot River at Gilsum, New Hampshire. Of these, the former has a drainage basin most similar in physical characteristics to Beaver Brook, and, therefore, was considered most representative of the runoff character of Beaver Brook. Based on streamflow data available from that gage, rainfall-runoff relationships were developed for the Beaver Brook watershed. Peak flows computed from this rainfall-runoff relationship compared favorably with peak flows estimated from experienced high water marks and developed stage-discharge relations. Based on this information, the storm of September 1938 is considered to have produced the record discharge on Beaver Brook, with estimated peak flows of 2,000 cubic feet per second (cfs).

## Flood History

Flooding on Beaver Brook has occurred many times in the past with the most notable events occurring in September 1938, October 1959 and December 1973. Peak discharges in the lower reach of the flood plain were estimated for these and other flood events and are presented in Table 1.

TABLE 1
ESTIMATED PEAK DISCHARGES
BEAVER BROOK

| Event | Peak Discharge, cfs |
|---|---|
| September 1938 | 2000 |
| October 1959 | 1100 |
| March 1936 | 900 |
| December 1973 | 900 |
| April 1960 | 600 |
| November 1950 | 500 |

In the lower reaches of Beaver Brook basin, flooding is caused by inadequate channel capacities and by the backwater influence of the Ashuelot River. During more frequent events flooding is mainly a function of the discharge in Beaver Brook and insufficient channel capacities. During more severe storms, flood stages on Beaver Brook become much more dependent upon the stage of the Ashuelot, and only major improvements along that river would alter this condition.

The existing discharge capacity of the Beaver Brook channel in the lower reach of the basin is about 300 cfs. By comparison, the estimated discharge of the 10-year flood event is 900 cfs. The last time Beaver Brook produced a discharge of this magnitude was in December 1973, when 3 inches of rain fell on snow covered ground, causing high rates of runoff from the entire watershed. This storm caused severe overbank flooding in the lower reach of Beaver Brook, particularly along Railroad and Water Streets, in part because icing conditions at Water Street further constricted the channel capacity.

Some improvements in the flooding problem can be made for minor flood events by widening the Beaver Brook channel and removing major restrictions to flow. However, because of the backwater influence of the Ashuelot River on Beaver Brook, there is a limit to the effectiveness of channel improvements in the lower reach. Plate 3 delineates the extent of the flood plain that would be inundated if a Standard Project Flood were to occur in the Beaver Brook Basin. A plan of channel improvements in Beaver Brook alone could not reduce this flood problem.

**Land Use**

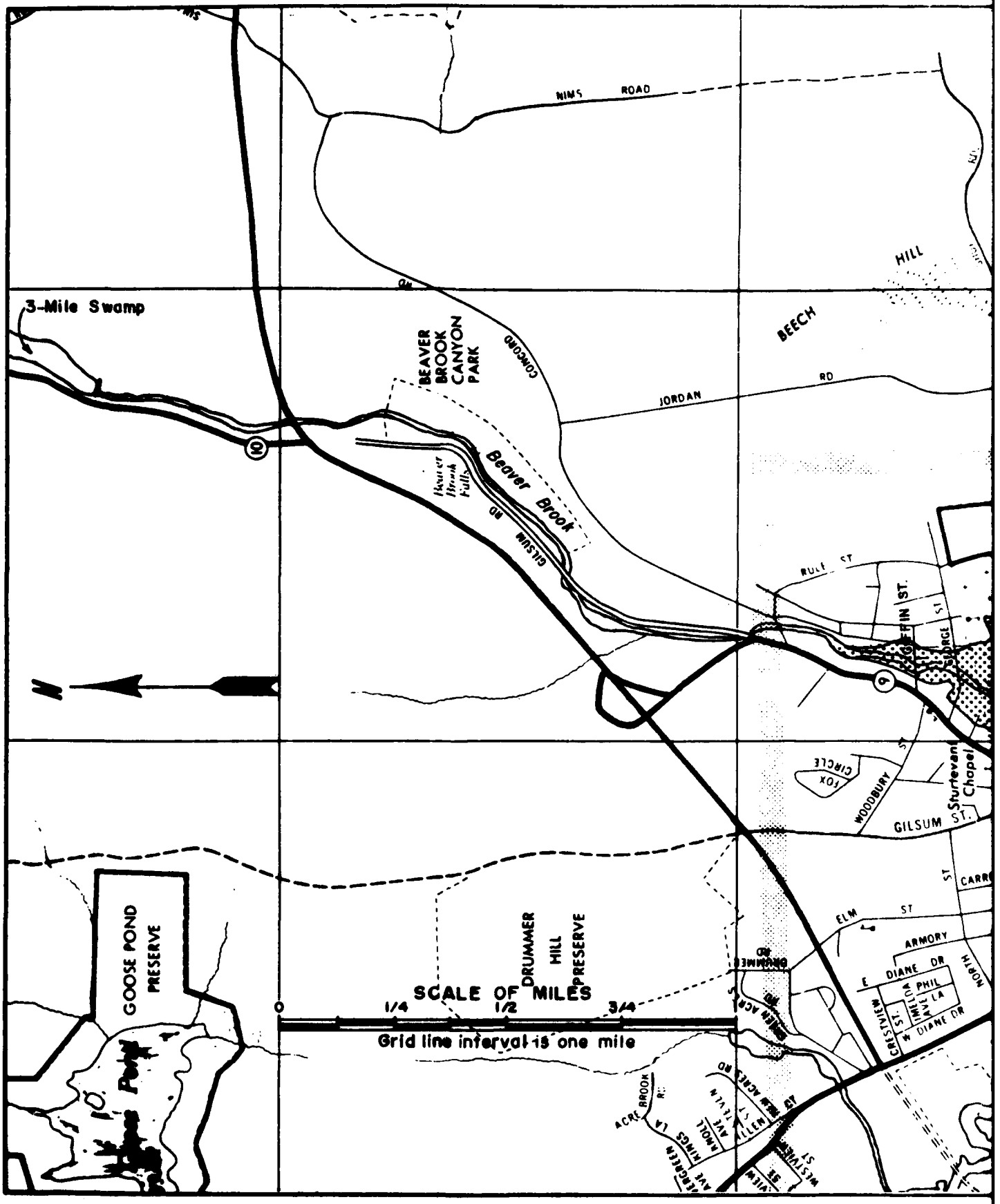
Land use patterns within the Beaver Brook watershed are consistent with the patterns that have developed city-wide. The upper watershed is characterized by undeveloped land, predominantly forested with major exceptions being the two wetlands at Gilsum and Three Mile Swamp. The lower Beaver Brook flood plain is the location of some of the oldest and most densely developed neighborhoods in Keene. As it falls toward the valley floor Beaver Brook flows through the open lands of the Woodland Cemetery and enters the medium to high-density residential neighborhood

between Beaver Street and Church Street. Here the flood plain is dominated by older, wood-framed, single and multi-family homes. South of Church Street the brook passes through an older section of Keene where the Boston and Maine Railroad served to focus the early industrial development of the city. The flood plain in this location widens to include commercial development along Railroad and Dunbar Streets, as well as some medium density housing at the fringes of the floodplain. The largest industrial complex within the Beaver Brook flood plain is that of the Kingsbury Machine Tool Corporation located over and adjacent to the brook, between Myrtle and Laurel Streets. Downstream of the Kingsbury plant the brook passes through more commercial development along Marlboro Street and then through a small open field and medium density single family housing south of Baker Street. At the confluence of Beaver Brook with the Branch, flood plain land use is predominantly commercial, located to serve the main arteries into the city.

Economy and Population

Although the residential neighborhoods along Beaver Brook house a porportionately higher number of lower and middle income families than the rest of the city, the economy of Keene's east side remains fairly stable and healthy. Based on a survey of housing conditions conducted by the city in 1979, it is known that families living in the flood plain are more likely to rent their homes than those living outside the flood plain, and that they tend to live in these areas for a longer period of time. Employment in Keene is more concentrated in manufacturing than is true of the rest of the state, with industrial concerns ranging from the production of toys and furniture to the production of intermediate goods such as machine tools. Merchants providing goods and services to the Cheshire County area contribute significantly to the employment opportunities of the city, and through the years Keene has sustained a steady and moderate rate of economic growth,with lower rates of unemployment than the remainder of the state. The population of Keene, listed by the 1980 census as 21,449, has also grown steadily throughout the past, although at a slower rate than the rest of the state. This comparison is attributed more to the sharp influx of people to the southeastern portion of the state than to a sluggish growth in Keene. Finally, it is generally believed that a tempering influence on Keene's economy is its isolation from the major transportation network of the state, and with better access to these roads Keene's rate of growth would improve. Table 2 below presents historical population figures for the city of Keene.

I


NIMS ROAD
HILL
3-Mile Swamp
BEAVER BROOK CANYON PARK
BEECH
JORDAN RD
Beaver Brook
GILSUM RD
RULF ST
GILSUM ST.
WOODBURY
FOX CIRCLE
ELM ST
ARMORY
E DIANE DR
W DIANE DR
PHIL LA
GOOSE POND PRESERVE
DRUMMER HILL PRESERVE
SCALE OF MILES
1/4
1/2
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Grid line interval is one mile
ACRE BROOK RD
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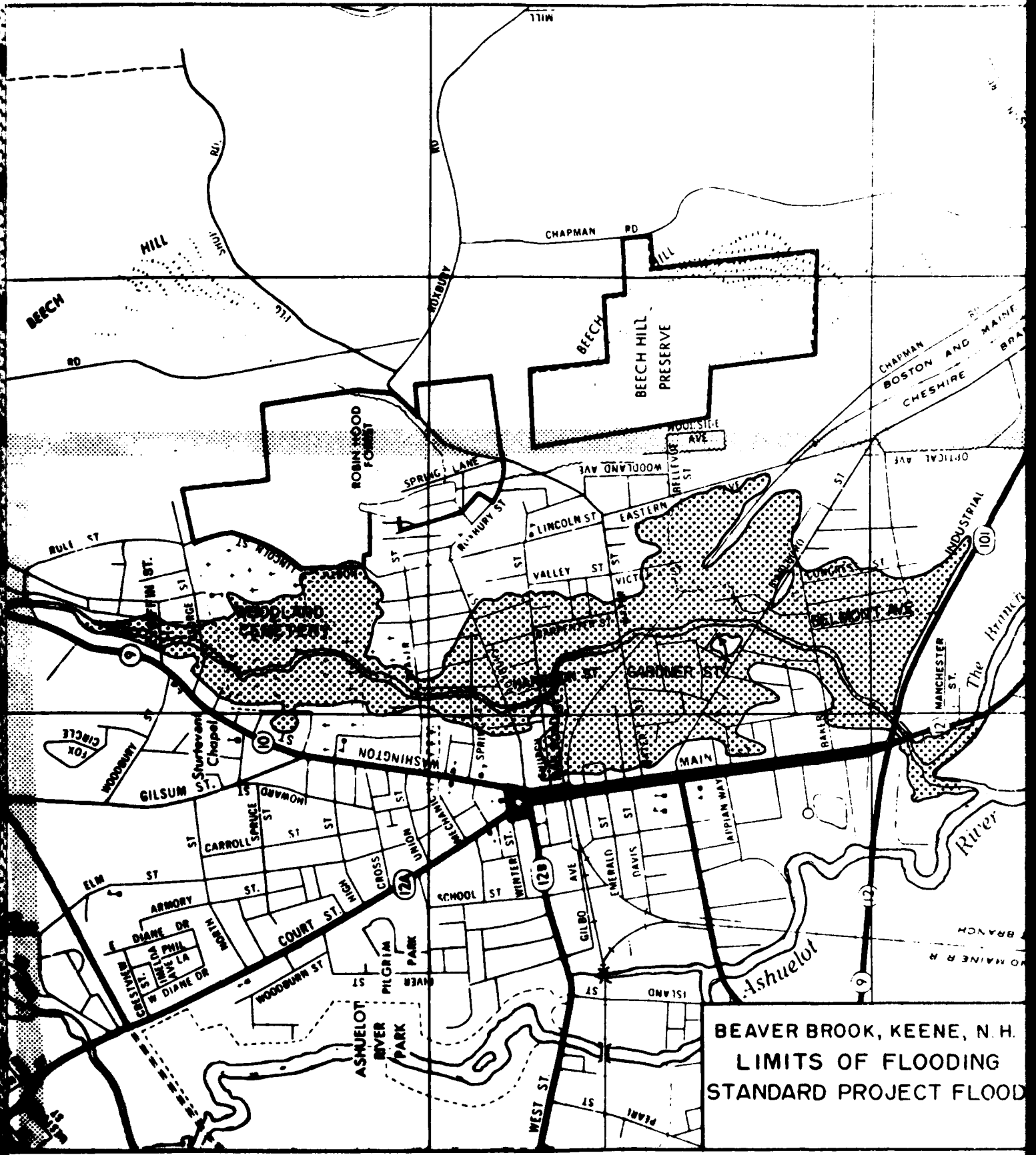



BEAVER BROOK, KEENE, N.H.
LIMITS OF FLOODING
STANDARD PROJECT FLOOD

PLATE

TABLE 2
POPULATION GROWTH
KEENE, NEW HAMPSHIRE

| Year | Population | Absolute Change | % Change |
|---|---|---|---|
| 1900 | 9,165 | - | - |
| 1910 | 10,068 | 903 | 9.9 |
| 1920 | 11,201 | 1,142 | 11.3 |
| 1930 | 13,794 | 2,584 | 23.1 |
| 1940 | 13,832 | 38 | 0.3 |
| 1950 | 15,638 | 1,806 | 13.1 |
| 1960 | 17,562 | 1,924 | 12.3 |
| 1970 | 20,467 | 2,905 | 16.5 |
| 1980 | 21,449 | 982 | 4.8 |

source: U.S. Census.

Environmental Setting

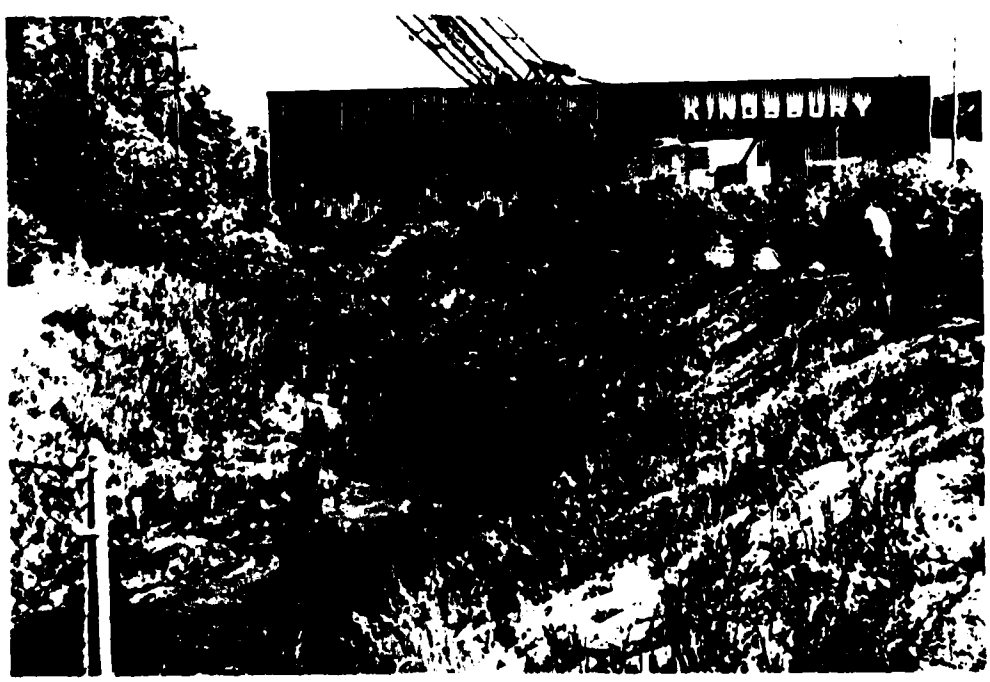
The existing environmental setting of the Beaver Brook watershed varies with the mixed topography of the land. In the upper reaches of the watershed, where the steep hillsides and fragile soils will not support extensive development, the land remains in its natural state, predominately forested with mixed hardwoods. Although there has been some clearing of white pines to the east of the Three Mile Swamp, there is not a significant lumber industry within the watershed, and it has been suggested that some of these lands be designated as permanent forest land. The Three Mile Swamp located along Beaver Brook is considered to be a productive and attractive wetland area. It has a normal surface area of about 30 acres and supports several different types of wetland, ranging from emergent wetland to scrub-shrub wetland. It supports chain pickerel, brown bullhead, yellow perch and various species of forage fish, such as shiners and darters. In the spring, a few trout may be found when they move downstream from the reach that is stocked by the New Hampshire Fish and Game Department. Beaver, muskrat, mink, otter, hare and white-tail deer are among the mammals that reside in the swamp or include it in their daily range. The swamp also provides a good habitat for gamebirds and songbirds, in addition to being visually appealing to passing travelers on Route 10.

In the downstream reach of Beaver Brook the environment of the flood plain and river channel can best be described as urban habitat, alternately passing through residential neighborhoods and industrial lots. Although adequate cover exists in several locations along the brook to provide shade and protection to small animals, the water quality is not adequate in the summer to sustain a cold water fishery. However, warmwater species such as common sucker, yellow perch, shiners and dace reside in and pass through the area. Based on the conditions of the Ashuelot River, the State of New Hampshire presumes that Beaver Brook contains class B waters. Class B waters are defined as being "acceptable for swimming and

other recreation, fish habitat, and, after adequate treatment, for use as water supplies. No disposal of sewage or wastes unless adequately treated. (High aesthetic value)".

Aside from providing some sport fishing for the younger residents of the flood plain, Beaver Brook does not represent a significant recreational resource. Within the floodplain there is a small playground area along Carpenter Street and within the greater Beaver Brook watershed there is the Robin Hood Park, located east of the brook, which provides a total of 127 acres of recreational lands to the general public.

BEAVER BROOK CHANNEL: Looking upstream behind Gardner Street

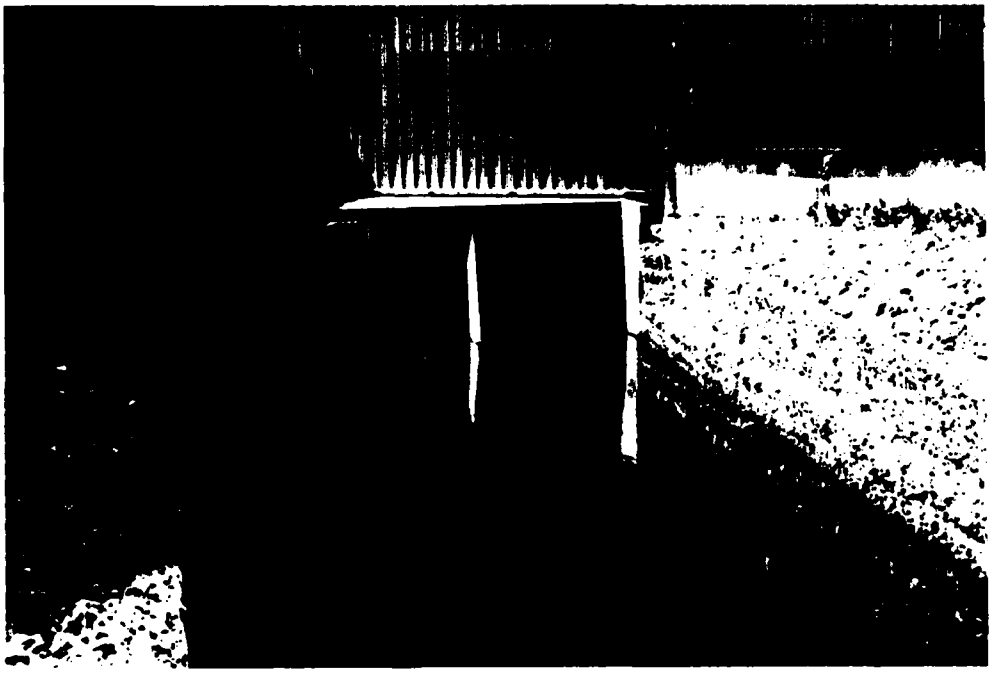



BEAVER BROOK CHANNEL: Looking upstream from Marlboro Street

BEAVER BROOK CHANNEL: Looking upstream
from Railroad Bridge

BEAVER BROOK CHANNEL: Looking upstream from behind
Kingsbury Machine Tool Co.

BEAVER BROOK CHANNEL: Looking Downstream from Railroad Bridge



Gabion-Lined Channel: Looking Downstream from Myrtle Street towards KMT culvert

View of Three Mile Swamp Dam from Route 10

View looking downstream from Three Mile Swamp Dam

Views of Three Mile Swamp looking upstream (top photo)
and dowstream from along Route 10

## PROBLEM IDENTIFICATION

### THE EXPECTED FUTURE

The following discussion focuses on the most probable future condition of the Beaver Brook watershed assuming that no new Federally-sponsored water resources project is developed in the area. This analysis, which covers a 100-year planning period, is intended to identify problems of the study area and to serve as a baseline against which the expected impacts of water resources project can be judged.

#### Future Population and Economy

Table 3 presents population projections for the city of Keene, as presented in the Keene Comprehensive Plan, and the alternative predictions of the New Hampshire State Planning Office. In general the city projects a 10 percent per decade growth rate for the next two decades, reaching a population of 25,600 in the year 2000. By comparison the State Planning Office only expects a 10 percent increase in population between 1980 and 2030.

Table 3
POPULATION PROJECTIONS
KEENE, NEW HAMPSHIRE

| Year | Keene Comprehensive Plan | State Planning Office |
|---|---|---|
| 1980 | 21,449 | 21385 |
| 1990 | 23,500 | 21901 |
| 2000 | 25,600 | 22400 |
| 2010 | - | 22908 |
| 2020 | - | 23126 |
| 2030 | 29,900 | 23547 |

Keene expects the above population projections to be sustained by the city's existing broadly based economic market, and by the influx of other industries into Keene. This influx is expected to result from the city's aggressive strategy for attracting businesses to Keene and because, in relation to other communities in the area, Keene has a good amount of land considered suitable for industrial development.

#### Future Land Use

The future development of Keene's land has also been addressed by the city in the Keene Comprehensive Plan, and will be controlled through the Zoning Ordinance amended in 1977. The most significant external influence on the

location of future development in Keene is the city's participation in the regular program of National Flood Insurance, which limits development activities within the flood plain. The most significant local policies affecting future land use are Keene's stated goal of maintaining 50 percent of its land as open space and its need to relate development to soil and slope stability. Keene's studies of soil and slope conditions around the city have indicated that it is not feasible to expand water and sewerage services to above elevation 620 feet NGVD. As a result, future development above this elevation will primarily consist of planned unit developments only where soil and slope conditions are suitable. In an effort to prevent future increases in flood losses, the city has a long range goal to acquire as much floodway land as is economically feasible. In spite of this goal, however, the city has estimated that 17 percent of Keene's theoretically developable land is located in the flood plain, and potentially 60 percent of these lands could be used for urban development. Over the next 20 years, the city realistically expects to develop 162 acres of flood plain for urban uses, representing an increase of 54 percent over the amount of flood plain lands currently used for these purposes. The most significant land uses proposed for the flood plain are industrial and commercial, with precautions taken to protect such development against flood losses.

Within the Beaver Book watershed the city expects to see some residential development occurring in the foothills around the flood plain, most notably between Gilsum Road and the Route 9 bypass, as well as across the valley from there on the eastern side of Beaver Brook. There are no major changes expected in the character of the Beaver Brook flood plain, primarily because it is already intensely developed. An intensification of commercial activities is expected to take place along Railroad Street, and some open space near Carpenter Street has been converted to public use. Conservation efforts along Beaver Brook have focused on the flood plain downstream of Baker Street, as well as on the recreational resources of the Beaver Brook Canyon and Three Mile Swamp. Although the Keene Comprehensive Plan mentions plans to designate the Three Mile Swamp and surrounding area as a wooded preserve, the city has taken no action to date to acquire this land. In the absence of a Federal project it is likely that this land will remain privately owned, protected only by zoning laws.

Future Environment

The environmental resources of the Beaver Brook watershed are not expected to change significantly over the project planning period, primarily because of the expected stability of current land use patterns. In the absence of a Federal project, the Three Mile Swamp will most likely remain in private ownership, and its preservation will be dependent on the enforcement of local zoning laws. There are no major plans on the part of the state to increase stocking operations along Beaver Brook since the current put-and-catch operations are basically adequate to meet present demands. Erosion and subsequent deposition of channel sediments will continue, since the profile of the river will basically remain unchanged.

## Future Flood Losses

In the absence of additional flood control improvements along Beaver Brook, residents of the flood plain can expect to continue experiencing nuisance flooding on an annual basis with wet basements and utility disturbances a common occurrence. Major floods, more dangerous in their threat to human health and safety, and more damaging in their destruction of property, will also continue unchecked. In total, there are approximately 384 residential, 45 commercial and 13 industrial units that would be effected during a Standard Project Flood on Beaver Brook. Flood damage surveys of these properties have been conducted to determine the range of losses likely to occur during all different flood events on Beaver Brook. To facilitate the comparison of alternative flood control improvements these flood losses have been converted to a single estimate of the average loss that could be expected to occur in any given year. The average annual loss is determined by adding together the weighted losses from all flood events likely to occur along Beaver Brook, where the weighted loss of a particular flood is equal to the loss expected to occur from that flood multiplied by the percent chance that a flood will occur in any given year. In February 1983 dollars, average annual flood losses to the Beaver Brook properties are estimated to total $447,000. If a single flood having a frequency of occurrence of once in 100 years were to occur today, it would result in approximately $4.4 million in losses. Table 4 presents additional information concerning flood losses along Beaver Brook.

TABLE 4
FLOOD LOSSES ON BEAVER BROOK
($1000)

| Reach | Average Annual Losses | Total Losses 100-YR Event | Total Losses SPF Event |
|---|---|---|---|
| 0 | 12 | 181 | 743 |
| 1 | 5 | 100 | 1029 |
| 2 | 88 | 1798 | 3389 |
| 3 | 249 | 1664 | 3085 |
| 4 | 24 | 281 | 612 |
| 5 | 69 | 338 | 498 |
| Total | 447 | 4,362 | 9,356 |

## PROBLEMS AND OPPORTUNITIES

The problems and opportunities discussed in this section, and the objectives statements which follow have been identified through an understanding of the existing character of the Beaver Brook watershed and through interaction with other State and Federal agencies and the general public.

## Flooding Problem

Recurring flood events along Beaver Brook have resulted in property damage, loss of heat and utilities, and the need for residents to evacuate their homes until access and services are safely restored. Even during minor floods, damages to key electrical equipment have caused long post-flood shutdowns to local industries, creating loss of work and revenues. For example, following the December flood of 1973 a wood working shop in the Beaver Brook flood plain was shut down for approximately 15 days because of damages to electric motors.

Flood losses in the Beaver Brook area are estimated to average $447,000 annually. The magnitude of these losses and the frequency of flooding illustrate the need for a solution to the flooding problem along Beaver Brook. The preparation of this Detailed Project Report has provided an opportunity to address this flooding problem.

## Environmental Opportunity

Among the strongest of Keene's community goals is the objective of maintaining 50 percent of the city's land as open space, and preserving the environment for the enjoyment of future generations. Addressing the flooding problems of the area also provides an opportunity to assist the city in achieving its environmental goals, by preserving or enhancing the ecological and aesthetic qualities of the Beaver Brook watershed.

## Problem and Opportunity Statements

Based on the above summary of problems and opportunities in the Beaver Brook watershed the following statements were developed to guide the formulation of a complete water resources project for Keene, and to serve as a standard against which the achievements of the alternative plans could be assessed. Basically, a complete water resources project in the Beaver Brook watershed should:

1. Reduce flood damages occurring along Beaver Brook in Keene, New Hampshire over a 100-year project life, and

2. Preserve and enhance the scenic and environmental qualities of the Beaver Brook watershed consistent with the city's goal to ensure its appreciation by future Keene generations.

## PLANNING CONSTRAINTS

Constraints to the planning process occur in two areas. First, the long history of flooding on Beaver Brook and the difficulty in the past to implement a flood control plan has left some Keene residents uneasy about the merits of a major flood control project, making it necessary to concentrate on smaller-scale improvements.

Second, funding limitations within all levels of government require the project to provide for essential needs only, in an effort to keep costs affordable.

## PLAN FORMULATION

The selection of a plan of flood protection for the Beaver Brook watershed has involved an iterative process of developing alternative solutions in increasing detail and screening those solutions to determine their applicability to the flooding problems of Keene. Although the initial stages of this process were accomplished in earlier studies, the results are related here to summarize earlier findings.

### PRELIMINARY SCREENING OF MEASURES

In the initial screening process different measures considered available to reduce flood damages were screened to determine their engineering and economic feasibility, and their acceptability to the local population. Basically these measures fall into two major categories: those which alter the nature of flooding, known commonly as structural measures, and those which minimize damages resulting from flooding, considered to be nonstructural measures. Table 5 presents a list of typical measures that fall into each of the two categories, after which the relative merits of these measures are discussed. All costs and benefits developed for the preliminary screening are expressed in May 1980 price levels.

TABLE 5
ALTERNATIVE MEASURES FOR
FLOOD DAMAGE REDUCTION

I. STRUCTURAL MEASURES
- A. Decrease Peak Flows
  1. Adjust runoff rate
  2. Increase or preserve storage
  3. Divert flood flows
- B. Decrease Peak Stage for Given Flow
  1. Increase channel capacity
  2. Reduce backwater influence
- C. Reduce Damaging Impact of Flood Flows
  1. Improve local drainage
  2. Construct walls and levees at critical areas

II. NONSTRUCTURAL MEASURES
- A. Reduce Damages
  1. Floodproof structures
  2. Raise structures
  3. Remove structures from flood plain
  4. Provide flood warning preparedness
  5. Control land use
- B. Mitigate Damages
  1. Flood insurance

Adjust Runoff Rate

Control of runoff from the upper basin of the Beaver Brook watershed is most critical in minimizing future flooding conditions resulting from future development. Presently this land is heavily forested and little can be done to reduce runoff from this terrain. However, with increasing pressures of urbanization from the city of Keene, precautions must be taken to limit the impact of future development on flood flows. This is particularly true in Beaver Brook where even the smallest storms cause out of bank flooding in the lower basin. The city of Keene has available two means of controlling development which in turn can be used to control future runoff. First, the city's zoning ordinance specifies that no increase in surface runoff from a given property shall result from development of that property unless this increased runoff can be channeled into an approved public storm drainage system. The second measure of control is through the Site Plan Review Process conducted by the Planning Board. All non-residential development is subject to this review. Since these policies are already implemented in Keene, this measure was not carried forward for further analysis. However, the city of Keene should be aware of Beaver Brook's susceptibility to increases in peak flow, and actively pursue control of the upper basin development.

Storage

Another more common method of reducing peak flood flows is to temporarily store flows in an upstream area away from damage areas, and gradually release these flows in a controlled and non-damaging fashion. With regard to Beaver Brook, upstream storage is considered to be a critical element of any plan to provide a high-level of flood protection, because once in the valley there is very little that can be done to reduce flood flows.

Earlier efforts by the Corps of Engineers to provide a high level of protection to the Beaver Brook floodplain resulted in Congressional authorization of the Beaver Brook Dam project in 1968. The authorized project would have provided 2750 acre-feet of flood control storage, enough to contain the SPF runoff from the upstream watershed. Discharges in the lower reaches of Beaver Brook would have been reduced about 60 percent as a result of upstream storage, translating into a 2-3 foot reduction in flood stages in the Roxbury Street area during moderate flood events. Although construction of the proposed project was initially supported by the city of Keene, eventually the cost-sharing requirements became too expensive for local participation and public support for the project was withdrawn.

Because it is widely accepted that a key element to providing SPF protection to the Beaver Brook floodplain is through a storage project of this magnitude, and because there remains in Keene an unfavorable atmosphere for consideration of such a large scale project, no attempts were made by this study to provide storage for SPF protection in the Beaver Brook floodplain. However, in spite of this history, flood control storage on a lesser scale was still investigated for its potential value in the Beaver Brook watershed.

In particular, the investigation focused on wetlands. Wetlands in their natural state provide some storage of flood flows when the water level in the wetland rises for a period of time, staying there until it is gradually drained off. Although the storage potential of a single wetland may be small, the cumulative effect of several wetlands within a watershed may be significant. Where flood damages along a river are particularly sensitive to changes in peak flow, as is true of Beaver Brook, the preservation of wetlands becomes an important element in plans to minimize future flood damages.

In the Beaver Brook watershed there are two significant wetland areas. The first is Three Mile Swamp located upstream of the Route 9 bypass, and the second is located further upstream, in Gilsum. Because the Gilsum wetland is located outside the Keene city limits, only Three Mile Swamp is within direct control of Keene, and the analysis has focused there. For the purposes of flood protection alone, the Section 73 study concluded that simple acquisition of the wetland for conservation purposes would have only marginal economic justification, since storage in the wetland occurs mostly during rarer flood events. However, since it is desirable to reduce flood flows for all events, the former investigation pursued the possibility of modifying the outlet of the wetland, to make it more effective during lesser storms. By making a modest alteration to the outlet structure, it was concluded that the flood modifying behavior of the Three Mile Swamp could be improved enough to render the alternatives economically feasible. Basically the modified structure would have provided three levels of spillway discharge: an orifice 8 feet long by 2 feet high at elevation 788 ft. NGVD, a 75-foot long spillway above that at elevation 793 ft. NGVD, and a second spillway 125 feet long at elevation 793.5 ft. NGVD. Based on preliminary analysis, this modification of the existing outlet structure would have an annual cost of $27,735, and would have resulted in $33,043 annually in flood control benefits. Since under preliminary analysis the modification of the wetland outlet structure had a 1.2 to 1.0 ratio of benefits to costs, this alternative was carried forward for additional study.

Divert Flood Flows

Another way to reduce peak flows through the damage areas is to divert damaging flood flows to another water course which can accommodate higher flows or divert to a point downstream of the damage area. Because the flooding problem in Keene is so extensive, the initial criticism of this

measure was that none of the adjacent watercourses could support additional flows without inflicting additional flood losses. However, since flood losses in Beaver Brook are so much higher than along other rivers in the Keene area, it was thought that even with a transfer in flood losses, such a measure might be economically justified. Therefore, the feasibility of diverting Beaver Brook flood flows north of the city and into the Ashuelot River was investigated. Even without considering the costs of increased flooding on the Ashuelot, the measure was too expensive, with estimated annual costs of about $500,000 and annual benefits of only $250,000. On this basis, this measure was eliminated from further consideration.

Increase Channel Capacity

Within a particular flood prone area, floodwaters escape the river channel when the discharge of a particular flood exceeds the carrying capacity of that channel. One of the solutions to this problem is to increase a channel's flow capacity and remove obstructions to flow, thereby lowering the flood stage associated with a given discharge. Since all channels have a limit to their capacity, residual flooding occurs during events larger than that for which the channel is designed. Channel capacities can be improved by several methods, including widening and deepening the channel, increasing the slope of the channel, or improving the flow characteristics within a given channel.

On Beaver Brook, constraints to a channel improvement project occur in two areas. First, the backwater influence of the greater Ashuelot valley floodplain limits the potential stage reduction that can be achieved on Beaver Brook without first constructing major improvements on the Ashuelot River. Second, existing channel improvements recently constructed along Beaver Brook have generally been designed for a flow of around 600 cfs. Although it would be engineeringly feasible to construct a larger channel on Beaver Brook, this would entail the reconstruction of two bridges (at Baker and Marlboro Streets) recently replaced by the city of Keene. Because under the Section 205 authority the cost of bridge replacements is a non-Federal responsibility, a plan calling for reconstruction of these bridges would not be an acceptable solution. For this reason channel improvements proposed by this investigation were designed to be compatible with the scope of existing improvements along Beaver Brook, and were focused only on the unimproved channel reach between Marlboro Street and Water Street. In particular it was estimated that a concrete lined channel 20 feet wide by 8 feet deep would produce $57,090 annually in flood damage reduction benefits. Costs for the project were estimated to average $67,650 annually, giving the channel a marginal benefit cost ratio of .84 to 1.0. Since it was considered that the cost of the channel could be reduced somewhat by altering the scope of improvements, the measure was carried forward for further study.

Reduce Backwater Effects on Flood Stage

During the former Section 73 investigation, consideration was also given to reducing the backwater influence of the Ashuelot River as a way to lower flood stages on Beaver Brook. That investigation proposed using the Route 101 by-pass embankment as a dike and installing a gate in the culvert to isolate Beaver Brook from the flood flows of the Ashuelot. This measure would require pumping Beaver Brook flood flows against the head of the Branch and the Ashuelot River, thereby lowering the water surface elevation at the mouth of Beaver Brook. It was hoped that a lowered water surface elevation at the mouth of the brook would improve the hydraulic gradient of the upstream river channel and allow it to pass flood flows more easily. A closer look at this measure revealed that the effect of the reduced backwater would not be experienced much further upstream of the Marlboro Street bridge, without constructing major channel improvements above this point. The economic analysis indicated this measure would have a benefit-cost ratio of 0.15 to 1.00 and therefore the measure was dropped from further consideration.

Improving Local Drainage

As a part of a comprehensive flood plain management plan, the improvement of local drainage facilities is critical to reducing damages related to the duration of flooding, rather than the stage of a flood. By increasing the speed with which floodwaters are drained from the flood plain, the losses that are related to the evacuation of homes and business can be reduced. It is doubtful that these losses could be eliminated by such a measure, since the reoccupation of homes is often related to the loss of services, determined by the stage of the flood. Nevertheless, the improvement of local drainage conditions is an important part of the total plan. The city of Keene has recognized this need and in 1962 commissioned Camp Dresser and McKee, Inc. to evaluate the drainage system on Beaver Brook and make recommendations as needed. The Capital Improvements Plan developed by the city for 1980-1984 called for drainage improvements at three locations along Beaver Brook. Because local drainage problems are beyond the Corps of Engineers authority for flood control improvements the city of Keene must accomplish this work independently.

Small Walls and Levees

Walls and levees (earth dikes) are generally used to prevent floodwaters from entering a damage-prone area. They can be constructed to protect an individual structure or groups of structures against damage, and in more comprehensive plans they can be used to confine floodflows to a particular channel.

With regard to Beaver Brook, small walls and earth dikes were considered only for the purpose of isolating structures from the flood plain. No attempt was made to use such measures to confine floodflows to the channel, since this would involve considerable disturbance to floodplain development.

Using the design elevation of the 100-year flood, walls and dikes to protect groups of structures were investigated for six locations along Beaver Brook during the Section 73 study. This initial screening assumed that access openings would be closed with sandbags during flood events, and that earth berms, with sides sloped to 1 vertical on 1 horizontal and no rock protection, would endure a 100-year flood event. Benefit cost ratios computed for these sites indicated that two areas on Beaver Brook would be worthy of further study and were carried forward for more detailed review. These were in the area of Manchester Street at the mouth of Beaver Brook and along Belmont Street downstream of Baker Street. The other locations were either not economically feasible or the height of wall required for protection would have interfered with the aesthetics or business nature of the structure.

Floodproofing

The underlying principal of floodproofing is that structures can be modified so that floodwaters no longer damage contents of a property. The leading flood problem in Keene is one of basement flooding and subsequent damage of utilities. In a floodproofing operation doors and windows are generally sealed to prevent the inflow of floodwaters. However, waterproofing becomes a much more expensive proposition when the foundations themselves are porous, allowing seepage of groundwater into the basement. This is frequently the case in Keene, where basements are constructed of fieldstone, brick and cinderblock. Further complicating the prospect of floodproofing is the fact that many of the structures in Keene's flood plain are very old, and are not designed to withstand the hydrostatic forces that would develop during a flood. Since this was considered to be the most common situation in Keene, floodproofing in the strict sense of the word was abandoned. However, many of the damages in Keene are attributed to the loss of utilities during a flood, most commonly the oil burner. Therefore, the Section 73 investigation did further analysis of the feasibility of protecting the utilities alone. Benefit-cost ratios developed for three different proposals ranged from 1.0 to 1.9 when applied to about 40 homes along Beaver Brook. As a result of the Section 73 investigation, a program of technical assistance was initiated to advise homeowners of the feasibility of installing such measures in their homes. Corps of Engineers involvement was not extended beyond this technical assistance since floodproofing of residential property on a large scale was not considered feasible for Federal participation.

Raising a Structure

In cases where first floor flooding occurs on a regular basis, consideration may be given to raising the foundation of that structure so that the elevation of the first floor is above some anticipated flood stage. Raising a structure is most practical in small buildings in which there is access below the first floor. These conditions really only apply

to residential structures, since major commercial and industrial structures are frequently constructed on a slab foundation. A preliminary analysis of flood prone structures along Beaver Brook indicated that this measure would not be economically justified.

Removal of Structures from the Flood Plain

In cases when floodproofing or raising of a building is infeasible because of the depth of floodwaters and the condition of a structure, the removal of that structure from the flood plain by relocation or demolition may be the only alternative available to eliminate flood losses. In assessing the merits of such a plan, it is assumed that structures located in the floodplain have a lower market value that reflects the flood losses which regularly occur to those structures. Therefore, benefits attributable to the relocation of a structure are limited to the reduction in costs normally borne by the general public in providing emergency assistance, shelter and food, as well as flood insurance subsidies to floodprone properties. In addition, a benefit can be taken if the land thus vacated can be put to a more valuable use.

With respect to Beaver Brook, the preliminary analysis established that the removal of structures from the floodplain would not be economically feasible, because, in spite of the flooding problems, property values in this area remain high enough to render this alternative too costly.

Floodwarning Preparedness Plan

As a last effort to provide some protection against flood losses, warning plans can be used to alert citizens of impending flooding so that they might evacuate the flood plain for personal safety and secure valuable property against expected flood waters. Warning systems rely on rain and stream gages positioned in the upper basin to monitor runoff and stream flows, and based on developed floodflow models, predict flood stages in the lower basin. Warning systems are most valuable for their ability to save lives. Beyond that they can serve to reduce economic losses if residents take precautions to elevate valuable property above the expected flood stage, or sandbag access points to their property. Since flood warning systems are relatively inexpensive to set up and have the potential to save lives, this alternative was considered worthy of further study.

Control Land Use

Finally, an important tool in the control of future flood losses is land use planning directed to limit the types of activities located in the flood plain. Keene has developed a land use plan which acknowledges the constraints it faces in attempting to minimize future flood losses. In an attempt to compromise between the intense pressures to develop in the floodplain, where costs are less, and to avoid increases in future damageable property, the city has adopted a plan whereby only certain

activities can locate in the flood plain. Along with this plan, the city proposes to acquire certain parcels of flood plain land as it becomes available, for use as open space. Although the allowance of flood plain development is not ideal, it is understood that the land use plan represents the city's best efforts to reach a compromise between these two pressing problems.

### Flood Insurance

Ultimately, some properties will never be completely protected against flood damage. For this reason the National Flood Insurance Program has been developed to help compensate flood plain residents for their losses. Although this insurance does not cover all the losses that may occur in a flood, it does cover property damage and loss of personal possessions to a much greater degree than disaster relief. Reimbursement is the primary function of the flood insurance program. However, as a precaution against future increases in flood insurance claims, communities enrolled in the regular program of flood insurance are required to implement land use controls which regulate different types of flood plain development. For instance, once a community has been accepted into the regular phase of the Flood Insurance Program, new residential properties located in the flood plain must have first floor elevations higher than the 100-year flood stage, and new commercial and industrial buildings must be floodproofed to the level of the 100 year flood. Of course, no development is allowed to occur within the floodway.

### Summary of Preliminary Screening

As a result of the initial screening process conducted during the Section 73 investigation, several measures of flood damage reduction were considered worthy of more detailed review. These included the modification of the outlet structure at Three Mile Swamp, construction of channel improvements in the lower flood plain of Beaver Brook, construction of walls and levees at isolated locations in the flood plain and the development of an automated warning system which would allow flood plain residents to prepare for a flood.

## SECOND STAGE SCREENING

Prior to incorporating these measures into alternative plans of protection for the Beaver Brook watershed, the validity of each measure was re-examined in a second, more thorough screening process, summarized below. Unless otherwise noted, all costs and benefits developed in the second stage screening are expressed in September 1982 price levels.

Modification of Wetland Storage at Three-Mile Swamp

Three Mile Swamp covers approximately 30 acres of land located adjacent to New Hampshire Route 10 about 4.5 miles upstream from the mouth of Beaver Brook. At present the water surface elevation of the swamp is about 787 feet NGVD and is controlled by a 190-foot long earth and stone-wall dam. This long weir results in large increases in outflow from the swamp for correspondingly small increases in surcharge storage. In order to improve the flood modifying potential of the Three Mile Swamp, the outlet structure of the swamp would have to be modified so as to utilize more of the swamp's storage capacity, and thereby reduce outflows.

Based on the preliminary design originally developed to evaluate this measure, a modified outlet structure having a 3-tiered spillway was developed and evaluated for its ability to modify downstream flood flows. The modified weir, slightly different than that originally proposed, would have an 8-foot width at elevation 787 feet NGVD, a 50-foot width at elevation 792 feet NGVD, and a final top width of 200 feet at elevation 794 feet NGVD. This structure would provide storage for 1.6 inches of runoff from the upstream drainage area of 6 square miles and would reduce wetland discharges during the estimated 100-year event from 1730 cfs to 1170 cfs. Stage and discharge modifications occurring during other events are tabulated below.

TABLE 6
PERTINENT STORAGE DATA
THREE MILE SWAMP

| Flood | Natural | | Modified | | |
|---|---|---|---|---|---|
| | Outflow (cfs) | Stage (ft NGVD) | Outflow (cfs) | Stage (ft NGVD) | Storage (inches RO) |
| Sept 1938 | 1340 | 791 | 1230 | 795 | 1.0 |
| Oct 1959 | 720 | 790.6 | 410 | 793.1 | .6 |
| 10 year | 680 | 790.6 | 370 | 792.9 | .5 |
| 100 year | 1730 | 791.3 | 1170 | 794.9 | 1.0 |
| SPF | 4300 | 792.7 | 3800 | 797.0 | 1.6 |

Based on a hydrologic analysis of the discharge-modifying effects of the outlet structure, and rating curves developed for the lower Beaver Brook channel, it was estimated that the proposed structure could reduce downstream river stages by 1 to 1.5 feet during the 10-year flood, with lesser stage reductions during rarer floods. A tentative economic analysis of this stage reduction indicated that flood damage reduction benefits would average about $220,000 annually.

The cost for construction of this modified outlet structure was estimated to total $350,000. Real estate requirements for the project would include the fee acquisition or purchase of flowage easements for all lands located below elevation 797 ft. NGVD, the SPF pool elevation, in addition to the

lands required for the project features themselves. This acquisition was estimated to cost about $72,000 bringing the total cost of this project element to $422,000. Amortized over a 100 year-period at an interest rate of 7-7/8 percent, the project would cost $33,200 annually, giving the project a benefit-cost ratio of 6.6 to 1.0. It was, therefore, incorporated into a plan of flood protection for Beaver Brook.

Channel Improvements in the Lower Reach of Beaver Brook

Also recommended after the initial screening of measures was the construction of channel improvements in the 1750-foot long reach between Marlboro Street and Water Street. The proposed improvements were basically consistent with Whitman & Howard's Phase II channel improvement recommendations for this reach, namely construct a 20-foot wide by 8-foot deep concrete lined channel throughout the reach and provide additional discharge capacity under the railroad tracks.

Subsequent to that preliminary screening, an initial cost estimate developed for this proposal totalled $1.5 million, not including project lands and easements. Since this construction cost was not economically feasible, further plan formulation was accomplished to modify the scope of the proposed plan. Subsequent formulation disclosed that gabio baskets and gabion slope protection should replace the proposed concrete lining, and that attempts to modify the discharge capacity under the railroad tracks be abandoned. By using these materials and modifying the configuration of the channel, while maintaining a modified cross-sectional area of 160 square feet, the cost estimate of this proposal was reduced to $390,000. Lands and easements were estimated at about $40,000, bringing the total cost to $430,000, which translated into an annual cost of $33,900.

The effect of the improved channel was analyzed using the HEC-2 Water Surface Profile computer program and was compared with a similar analysis of the channel under existing conditions. The analysis indicated that the channel improvements would lower flood stages in the reach extending from Marlboro Street upstream to Roxbury Street only, and that these stage reductions would most likely be experienced during smaller floods only. In addition, the analysis was conducted for two flow conditions, one assuming discharges were already being modified by improvements constructed at Three-Mile Swamp, and one assuming no discharge modifications were in effect. Benefit calculations for the channel improvements varied between the two conditions, because the upstream storage project would already have reduced flood losses associated with higher stage floodwaters, leaving the channel to reduce lower stages where fewer flood losses occur. The results were as follows: assuming that the channel was acting on its own, annual benefits totalled $57,000; assuming the channel was acting after the Three Mile Swamp had already modified stages, annual benefits totalled $36,000. The resulting benefit cost ratio for these two conditions was 1.7 to 1.0 and 1.1 to 1.0 respectively.

Although in the second case the benefits were sufficient to only marginally justify the cost of improvements, these channel improvements were considered to be extremely important to the flood plain residents and, therefore, the measure was incorporated in a plan for more detailed design.

Small Walls and Levees

The last structural measure considered feasible after the initial screening was construction of small walls and levees at two locations along Beaver Brook. These were at Manchester Street and Belmont Avenue, in the lower reach of Beaver Brook.

The design level of protection in each of these locations was the 100-year flood with provisions for one foot of freeboard. Normally in urban areas the Corps of Engineers' policy is to provide a level of protection equal to the Standard Project Flood. However, in the case of Beaver Brook, the lower level of protection was considered acceptable since overtopping of the walls and levees would not cause catastrophic or life threatening circumstances. However, if a lower level of protection is provided by such structures, provisions must be taken to design them to withstand the overtopping forces of the larger floods. The walls and levees proposed for Beaver Brook were, therefore, re-examined in this light, and were found to be economically infeasible. Table 7 below shows the results of the cost and benefit analysis for construction of walls and levees at the locations on Beaver Brook, assuming the structures were designed to resist overtopping.

TABLE 7
COSTS AND BENEFITS OF SMALL WALLS & LEVEES
100-YEAR FLOOD PROTECTION

| | Construction Cost | Annual Cost | Annual Benefit | B/C Ratio |
|---|---|---|---|---|
| Belmont Avenue | $203,000 | $16,000 | $1,500 | 0.1 to 1.0 |
| Manchester Street | 101,000 | 8,000 | 3,200 | 0.4 to 1.0 |

Since there is only a 1.5 to 2.0-foot difference in elevation between the stages of the 100-year and Standard Project Floods in this area, further attempts to provide SPF protection were made in the hope that, by eliminating the need to design against overtopping, costs might be reduced. However, the topography of the Beaver Brook flood plain in these areas does not enable construction of this level of protection without going to excessive lengths to tie into high ground. Therefore, the provision of SPF protection was not economically justified at these locations either, and small walls and levees were dropped from further consideration.

Flood Warning System

The last measure brought forward for further review was the provision of an automated flood warning system for the Beaver Brook basin. During preliminary screening this measure was found to have a benefit to cost ratio of about 7 to 1, but this analysis did not account for the cost of equipment replacement needed throughout the life of the project.

As a result of coordination with the National Weather Service, it was estimated that a computer, 2 raingages and a stream gage, properly positioned in the basin, could provide downstream residents with 2 to 3 hours of warning time before the onset of a flood. Based on a design life of 10-years, this flood warning equipment would have to be replaced 10 times to provide a design life equivalent to those of as the alternative plans. The total cost of this equipment was estimated at $30,300 (2/83 price level). Assuming that the equipment would have an average design life of 10-years, this system would have annual costs of $5,300.

Benefits to a warning plan were estimated using the same rationale followed in the Section 73 investigation. For the purposes of this analysis, the following assumptions for residential properties were made:

(1) 75 percent of residential losses are physical
(2) 10 percent of physical losses occur to moveable goods
(3) 50 percent of these losses would be avoided by moving the goods after receipt of warning.

Similar assumptions were made for commercial and industrial properties as follows:

(1) 30 percent of commercial and industrial losses are to contents and equipment
(2) 10 percent of these damages would be eliminated by moving contents and equipment upon receipt of warning
(3) the movement of contents and equipment has associated costs.

Based on the above assumptions, average annual benefits along Beaver Brook would be as follows:

| | | | |
|---|---|---|---|
| Residential | $160,000 X 75% X 10% X 50% | = | $ 6,000 |
| Commercial & Industrial | $270,000 X 30% X 10% X 50% | = | 4,000 |
| | TOTAL BENEFIT | | $10,000 |

This analysis results in a benefit to cost ratio of 10,000/5,300 = 1.9 to 1.0, making a warning plan worthy of further consideration.

## DESCRIPTION OF ALTERNATIVE PLANS

Arising from the screening of alternative measures are three plans which have been developed to reduce flood damages along Beaver Brook in Keene. This section describes those alternative plans and examines the impacts most likely to result from their implementation. Benefits and costs are expressed in February 1983 price levels.

### Plan A - Structural Alternative

Description - Plan A would use structural measures to reduce flood damages along Beaver Brook. Basically it would consist of two elements:

(1) modification of the outlet structure at Three Mile Swamp to augment the existing storage capacity of the wetland; and

(2) construction of channel improvements in the 1750 foot long reach of Beaver Brook between Water Street and Marlboro Street.

A detailed description of each of these measures follows.

The proposed modification of the outlet structure at Three Mile Swamp would basically involve replacement of the existing earth and rock wall dam with a concrete gravity dam having a self-regulated spillway section. The spillway would be designed in a stepped configuration so that the wetland would maintain its existing water surface elevation during non-flood periods, and temporarily store floodwaters in the wetland during flood periods. The existing outlet structure at Three Mile Swamp is an old earth and stone dam about 3.5 feet high and approximately 190 feet long. The top of the stone weir varies from elevation 791 feet NGVD at each end to approximately elevation 787 near the centerline of the brook, where several rocks have fallen away from the structure. The normal water surface elevation of the wetland pool is approximately 787 feet NGVD. The river channel downstream of the dam is approximately 20 feet wide and has an invert elevation of 783 feet NGVD.

The proposed outlet structure would be a concrete gravity dam approximately 250 feet long with a top elevation of 799 feet NGVD. The self-regulating spillway would have an 8-foot width at elevation 787 feet NGVD, a 50-foot width at elevation 792 feet NGVD, and a 200-foot width at elevation 794 feet NGVD. This spillway configuration would store runoff during flood periods but would maintain the existing pond elevation during other periods. In conjunction with the modified outlet structure a stilling basin would be constructed at the downstream toe of the dam to dispel the energy of spillway discharges. This stilling basin would extend along the full 200-foot width of the spillway for a distance of 20 feet downstream of the toe. The floor elevation of the stilling basin would be at 779 feet NGVD, 8 feet below the first spillway section. Because of the suspected bedrock profile in this location, the northern portion of this stilling basin would consist of a concrete slab founded on

bedrock, while the remaining section would be excavated from bedrock. Downstream of the stilling basin the width of the raceway would gradually taper down to meet the existing stream channel 200 feet downstream of the dam. Portions of the raceway would be excavated from bedrock. The remainder would be excavated from the overburden and lined with riprap stone protection. Plans and cross sections of the outlet structure and stilling basin are shown on Plates 4 and 7.

Upstream of the modified outlet structure pool levels during the Standard Project Flood are expected to reach a stage of 797 feet NGVD. Because the road surface of the adjacent N.H. Route 10 is below this elevation for a distance of several hundred feet upstream of the dam, the non-overflow portion of the dam has been extended upstream, using a dike to contain SPF stages. The dike would have a top width of 12 feet at elevation 799 feet NGVD, providing 2 feet of freeboard above the SPF pool elevation of 797 feet NGVD. It would extend for a distance of 1100 feet upstream of the dam, and would be located just east and parallel to N.H. Route 10, as shown on Plates 5 and 6. The dike would be constructed of compacted gravel and impervious fill, as shown in the typical cross sections on the above Plates. Stone slope protection would be placed on the wetland side of the dike while the remaining face would be layered with topsoil and seeded. The height of the dike above the road surface of Route 10 would vary linearly from 7 feet at the dam to 2 feet about 1100 feet upstream of the dam.

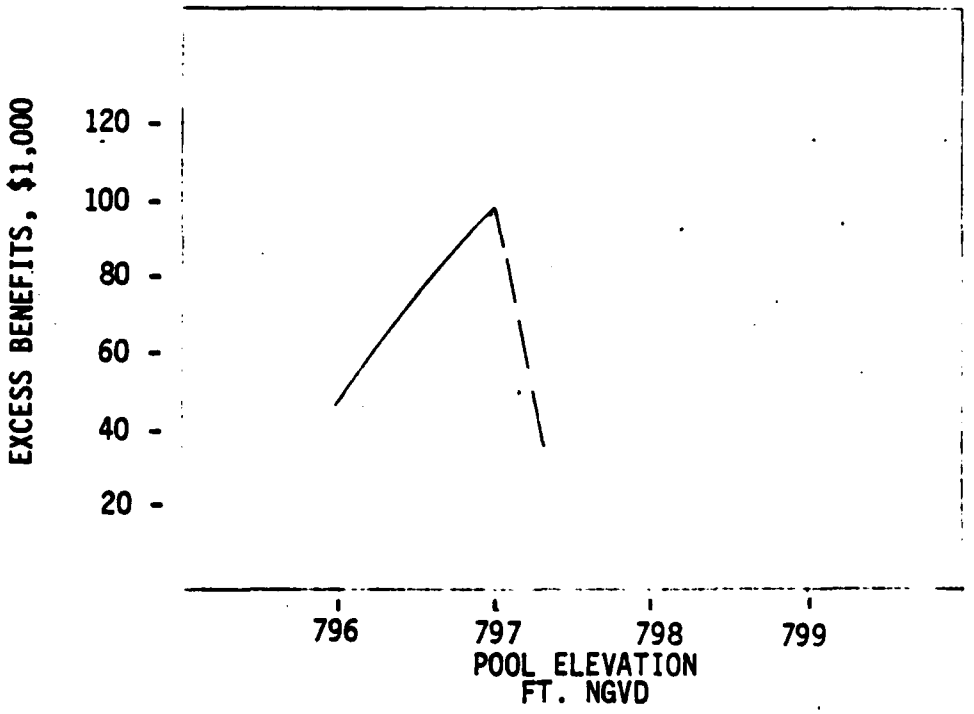
The proposed improvements at the outlet of Three Mile Swamp should not be viewed as a flood control dam, because these modifications are not designed to eliminate flooding on Beaver Brook. Instead the improvements should be viewed as measures which capitalize on the wetlands' effectiveness as a natural flood retention area.

The extent to which this natural storage area was utilized was established by analyzing the relative economic merits of several different volumes of storage, and selecting the plan that maximized net economic benefits (net economic benefits are equal to the difference between annual benefits and annual costs). The development of the Three Mile Swamp as a storage area is limited by site conditions, namely the location and surface elevation of N.H. Route 10 adjacent to the Swamp. Because of the low elevation of Route 10, very little storage is available in the Swamp before the pool overtops the roadway. To obtain additional storage, either Route 10 would have to be raised or a dike constructed along the roadway. The length of dike along the roadway is limited by the presence of a culvert approximately 1150 feet upstream of the outlet, which discharges into the Swamp. The recommended storage plan provides for construction of an 1100-foot dike along the roadway up to a point where the road elevation is approximately 797 feet NGVD. The annual cost of this plan is estimated at $107,600; when compared with annual benefits of $205,300 annually, this plan would have a net economic benefit of $97,700.

Two alternatives to this storage plan were also considered. A storage plan with a design pool elevation of 796 feet would provide less storage

and, therefore, fewer flood control benefits ($151,000 annually) but would also require a smaller dike over a shorter distance - 900 feet. In addition, the cost of the outlet structure would also be reduced because of the lower spillway elevations required. This alternative storage plan would have an annual cost of $102,500, giving the plan a net economic benefit of $48,500.

A higher pool elevation than the recommended plan would require reconstruction of the Route 10 roadway to maintain control of the drainage area west of the roadway and to avoid some of the adverse impacts of a dike. The extensive costs required to raise the roadway 6 or more feet would exceed the potential benefits of any incremental storage thus obtained, and, therefore, net economic benefits would also decline. The graph below indicates the relationship between different design pool elevations and net economic benefits, indicating that the selected plan optimizes the level of development of the Three Mile Swamp.




The second measure proposed in Plan A is the construction of channel improvements in the reach between Water Street and Marlboro Street. Basically the proposed improvements are designed to alleviate out-of-bank flooding during smaller more frequent flood events along Beaver Brook. The design of a more comprehensive channel improvement plan which would convey a rare flood event would require modifying several major bridges recently replaced by the city of Keene, and achieving a significant reduction in the backwater influence of the Ashuelot River. Such a

comprehensive plan was viewed as being economically infeasible, therefore, efforts have been concentrated on a less comprehensive plan.

Basically the proposed channel improvements involve widening and lining the Beaver Brook channel between Water Street and Marlboro Street. During the final stages of planning, detailed topographic surveys and cost estimates revealed that a trapezoidal channel would be less costly than the gabion-lined vertical channel proposed during the secondary screening phase. The modified trapezoidal channel would have an average depth of 7 feet, a bottom width of 17 feet and sides sloped to 1 vertical on 2 horizontal. Although these improvements would require deepening the channel in some locations, the overall slope would remain as it is now, with no modification to the existing invert elevations at Water Street or Marlboro Street. To protect the fine embankment materials against possible erosion, the lower portion of the improved channel, up to 4 feet above the channel invert, would be lined with a 1-foot layer of gravel bedding and a 2-foot layer of vandal-proof stone protection.

Above 4 feet, flood tolerant grasses planted in topsoil are considered sufficient to stabilize the bank materials. Use of grass along the upper bank would be discontinued within 50 feet upstream and downstream of bridges, where stone slope protection would extend up to the top of bank. The invert of the channel will be sloped gradually to the centerline of the improved channel, to provide a water depth of about 1-foot during the dry season. This will help mitigate the effects of channelization on the fishery resources of Beaver Brook. Plans and cross sections of the proposed channel are shown on Plates 8 through 10.

Implementation of the two proposed items of improvement in Plan A would result in impacts of both short term and long term duration.

Short Term Impacts- These impacts are generally related to construction of the project, and are primarily environmental in nature. Construction of the new outlet structure at the Three Mile Swamp would involve the temporary lowering of pool levels behind the dam, and construction of steel sheeting and earth or concrete cofferdams to dewater the construction site. Stripping activities along the alignment of the dike and excavation of the old dam and tailrace area would be accomplished in the dry to avoid siltation impacts to the brook. During part of the construction period outflows from the swamp would be diverted away from the normal outlet channel while the first portion of the outlet structure was completed. After that flows would be restored to the main channel while the remaining portion of the outlet structure was completed. Construction of the dike would occur simultaneously with no significant impacts occurring other than some minor disruption of traffic along Route 10.

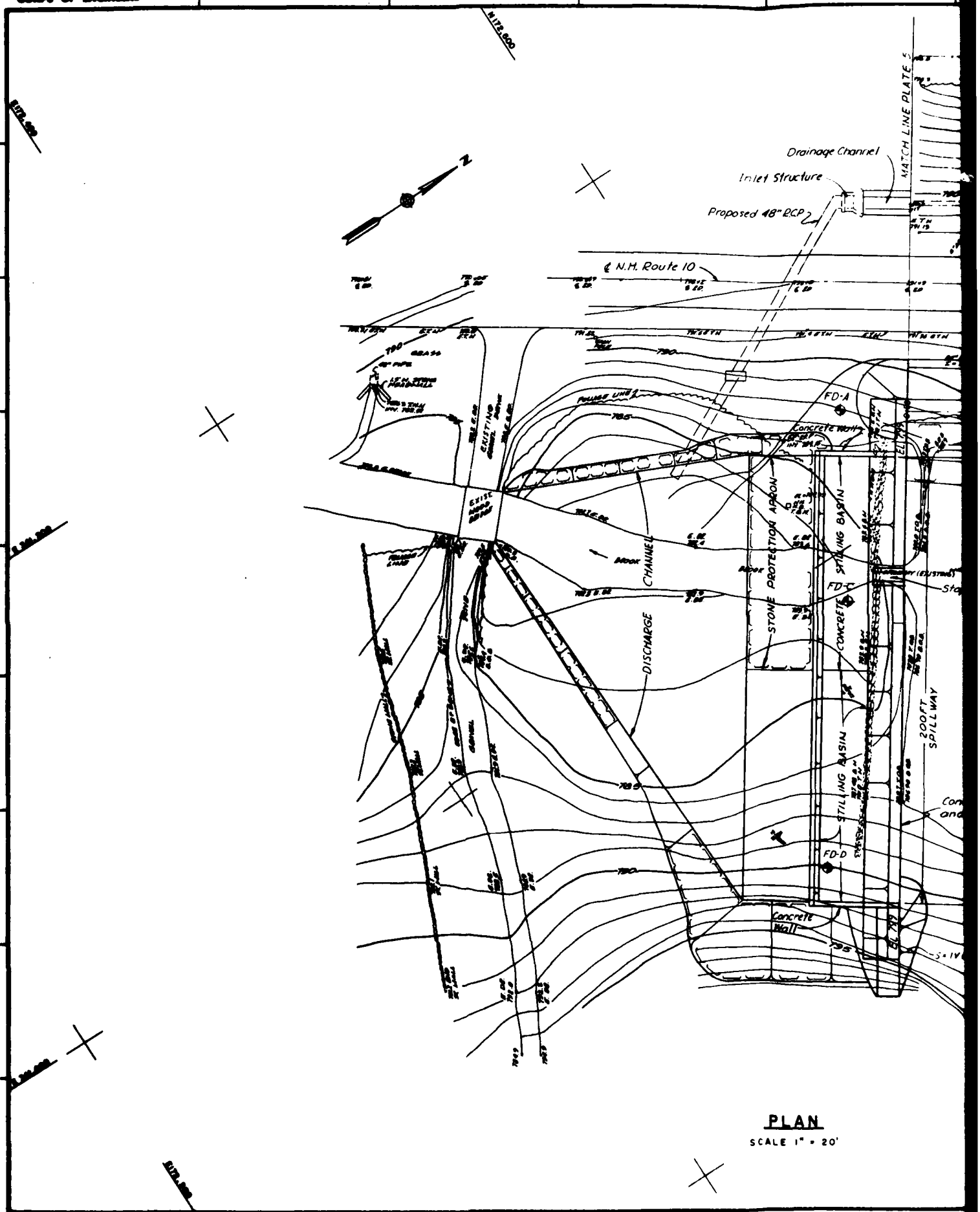
In the downtown area of Beaver Brook where channel improvements are proposed, short term impacts of construction would mostly be related to the excavation of streambed and bank habitat along the 1750-foot reach of

improvements. Increased siltation would temporarily degrade the existing water quaiity of the brook, however the use of siltation control measures would confine these impacts to the work area and minimize downstream impacts.

Other short term impacts resulting from construction of both project elements would involve the inconvenience of construction traffic in the area as well as an increase in noise and dust pollution throughout the construction period. Although the majority of the construction work involves the new impoundment structure at Three Mile Swamp, this area is removed from any residential development and the impacts mentioned above are not expected to cause a problem. It is more likely that the proposed channel improvements would cause a greater disturbance, particularly to the residential neighborhood around Gardner Street. Since the scope of channel work is fairly limited, this disturbance is expected to be of short duration. Finally, the presence of construction workers in the community may stimulate the commercial and service sectors of the local economy.

Long Term Impacts- Implementation of Plan A would also have impacts that could be expected to extend over the lifetime of the project which would be both regional and site-specific in nature. The most significant of these would be the reduction in recurring flood losses to properties located in the Beaver Brook floodplain. Of the two proposed items of improvement in Plan A, the modification of the Three Mile Swamp outlet structure would have the greater effect on flood flows, lowering stages throughout the downstream reach. Outflows from the swamp would be reduced by almost 50 percent in the 10 year event, translating into stage reductions of about one to one and a half feet throughout the flood plain. Flood stages experienced in December 1973 would be reduced by about 15 inches in the vicinity of Roxbury Street and 20 inches near Water Street. In addition to these reductions, flood stages in the reach between Roxbury Street and Marlboro Street would be further reduced as a result of the proposed channel improvements. For example, the combined effect of both project elements would reduce 10-year flood stages by more than one and a half feet in Reach 2 and by more than two and a half feet in Reach 3. These stage reductions would result in fewer properties being effected during a 10-year event with fewer economic losses as a result. Locally this would prove beneficial in terms of reducing some of the anxiety and risk of safety associated with frequent flooding, and regionally it would lessen the burden placed on the National Flood Insurance Program, which reimburses property owners for some of their losses.

It is important to note that neither of the flood control improvements proposed by this plan would provide a high degree of flood protection along Beaver Brook. In fact, flood stages during the estimated 100-year event would be reduced by less than half a foot as a result of upstream




PLAN

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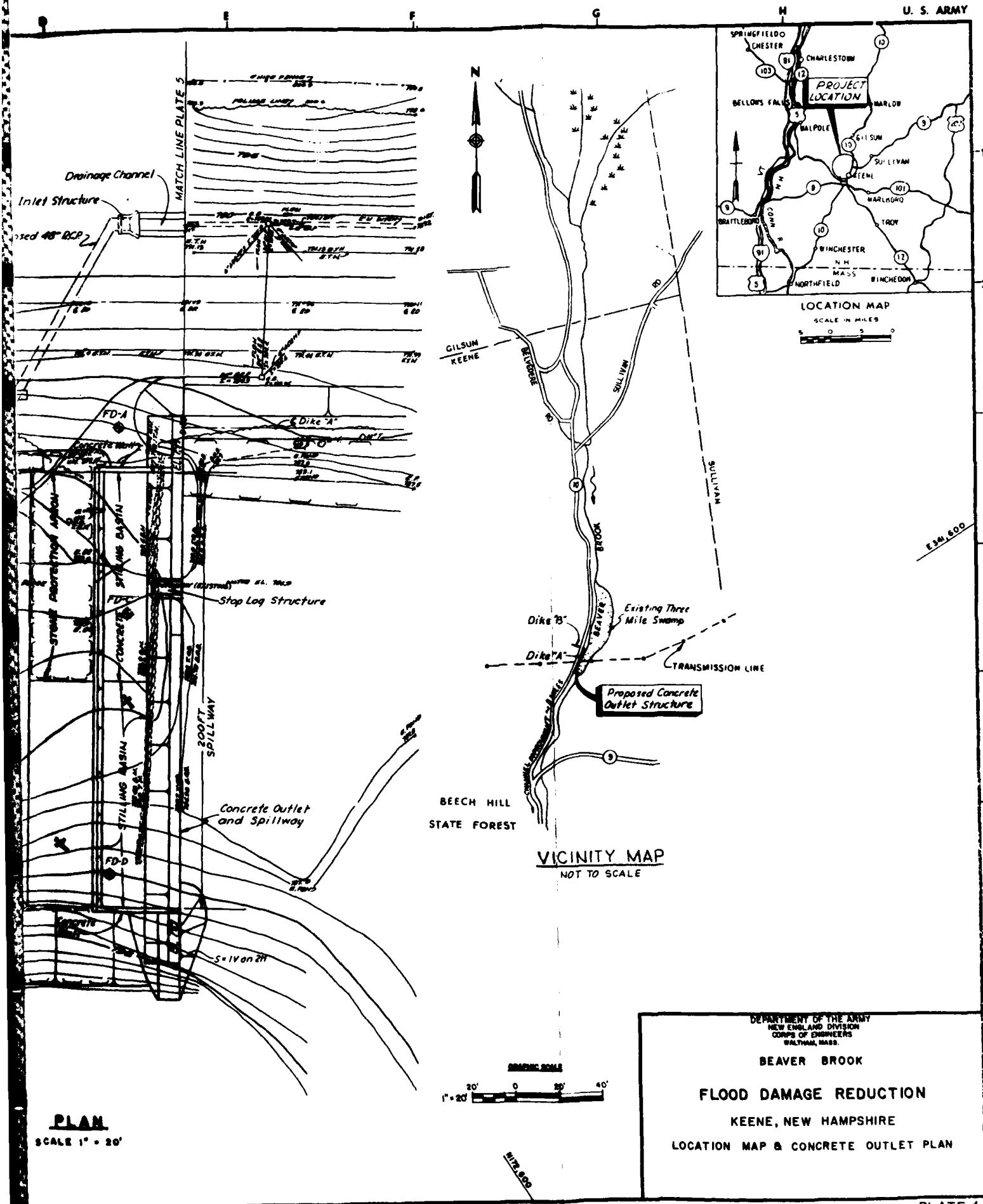
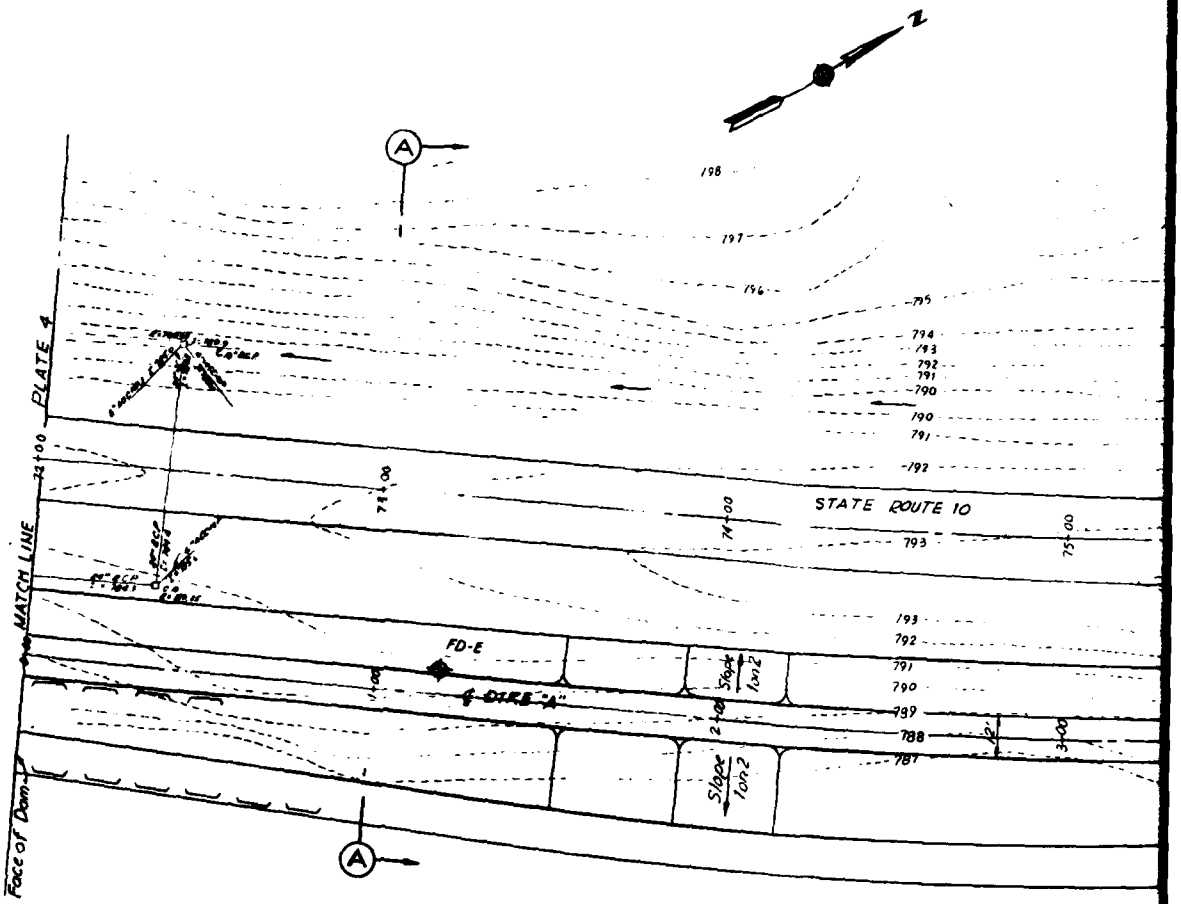

U. S. ARMY
E
F
G
H
MATCH LINE PLATE 5
Drainage Channel
Inlet Structure
Proposed 48" RCP
FD-A
Dike "A"
FD-C
Stop Log Structure
STONE ABERRATIONAL APRON
STILLING BASIN
CONCRETE
200 FT SPILLWAY
FD-D
Concrete Outlet and Spillway
S=1V on 2H
PLAN
SCALE 1" = 20'
N
GILSUM
KEENE
BELLOWS FALLS
SULLIVAN
BEAVER BROOK
Dike "B"
Dike "A"
Existing Three Mile Swamp
TRANSMISSION LINE
Proposed Concrete Outlet Structure
BEECH HILL
STATE FOREST
VICINITY MAP
NOT TO SCALE
GRAPHIC SCALE
1"=20'
20' 0 20' 40'
SPRINGFIELD
CHESTER
CHARLESTOWN
PROJECT LOCATION
MARLOW
WALPOLE
GILSUM
SULLIVAN
KEENE
MARLBORO
BRATTLEBORO
TROY
WINCHESTER
N.H.
MASS
NORTHFIELD
WINCHEDON
LOCATION MAP
SCALE IN MILES
5 0 5 10
E 341,600
N 178,600
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
BEAVER BROOK
FLOOD DAMAGE REDUCTION
KEENE, NEW HAMPSHIRE
LOCATION MAP & CONCRETE OUTLET PLAN
PLATE 4

2

CORPS OF ENGINEERS

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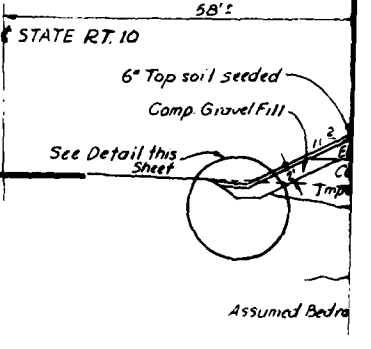
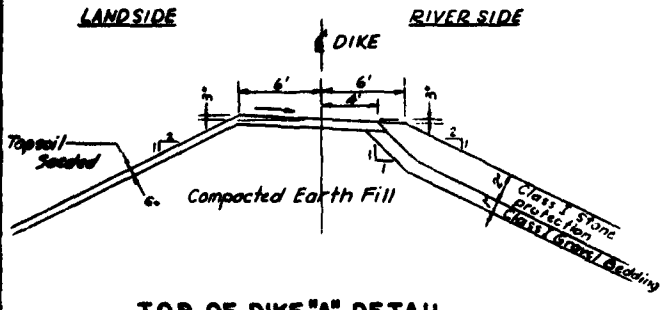
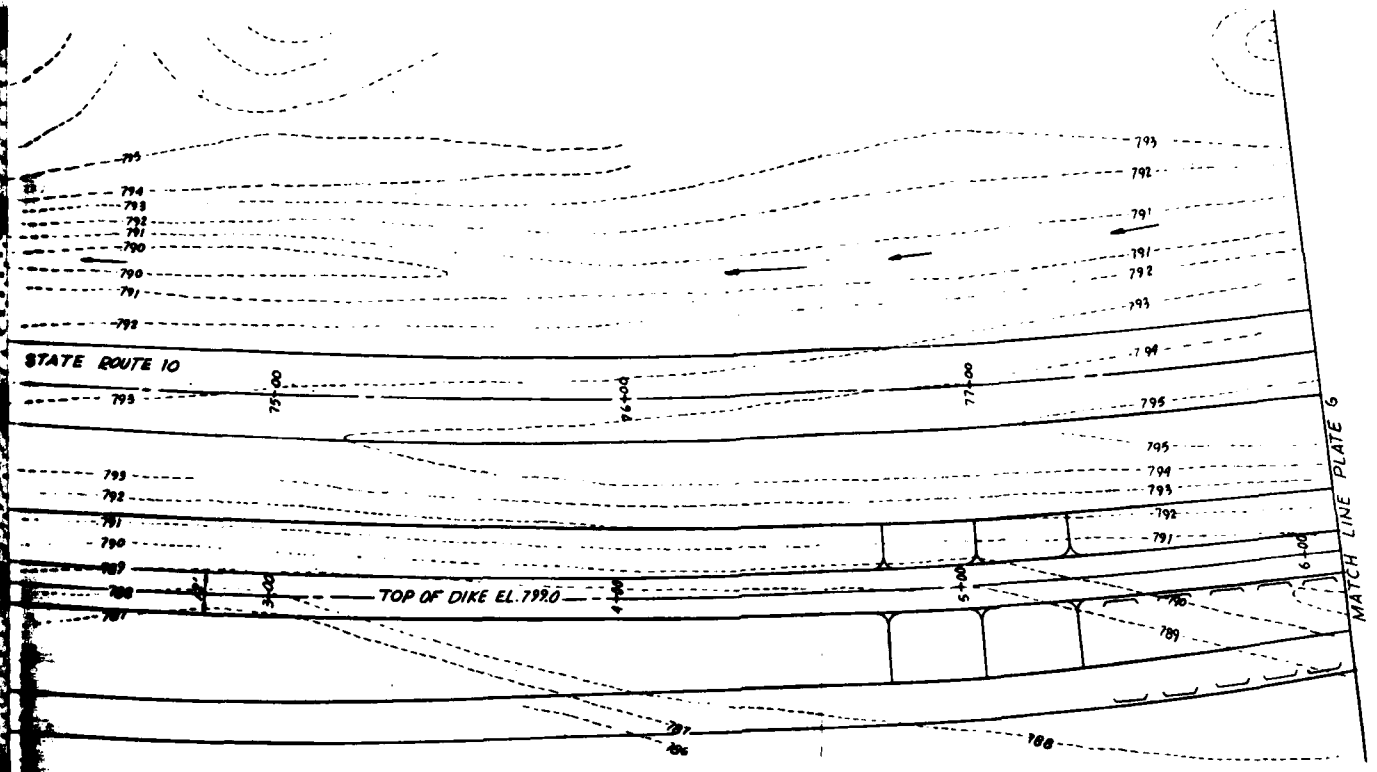



## SECTION A-A
SCALE 1" = 10'




## TOP OF DIKE "A" DETAIL
NOT TO SCALE

1

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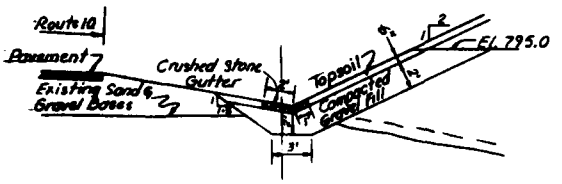
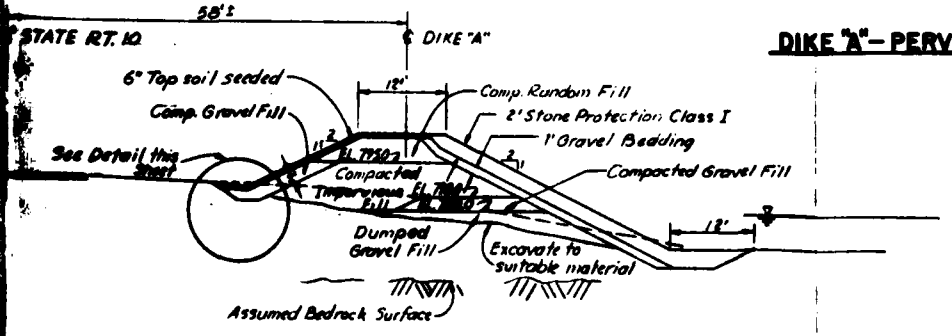



## SECTION A-A
SCALE 1" = 10'

## DIKE "A" – PERVIOUS TOE DRAIN STATION 0+00 TO 4+00
NOT TO SCALE

DRAWING SCALES
1" = 20' 20' 0 20' 40'
1" = 10' 10' 0 10' 20'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

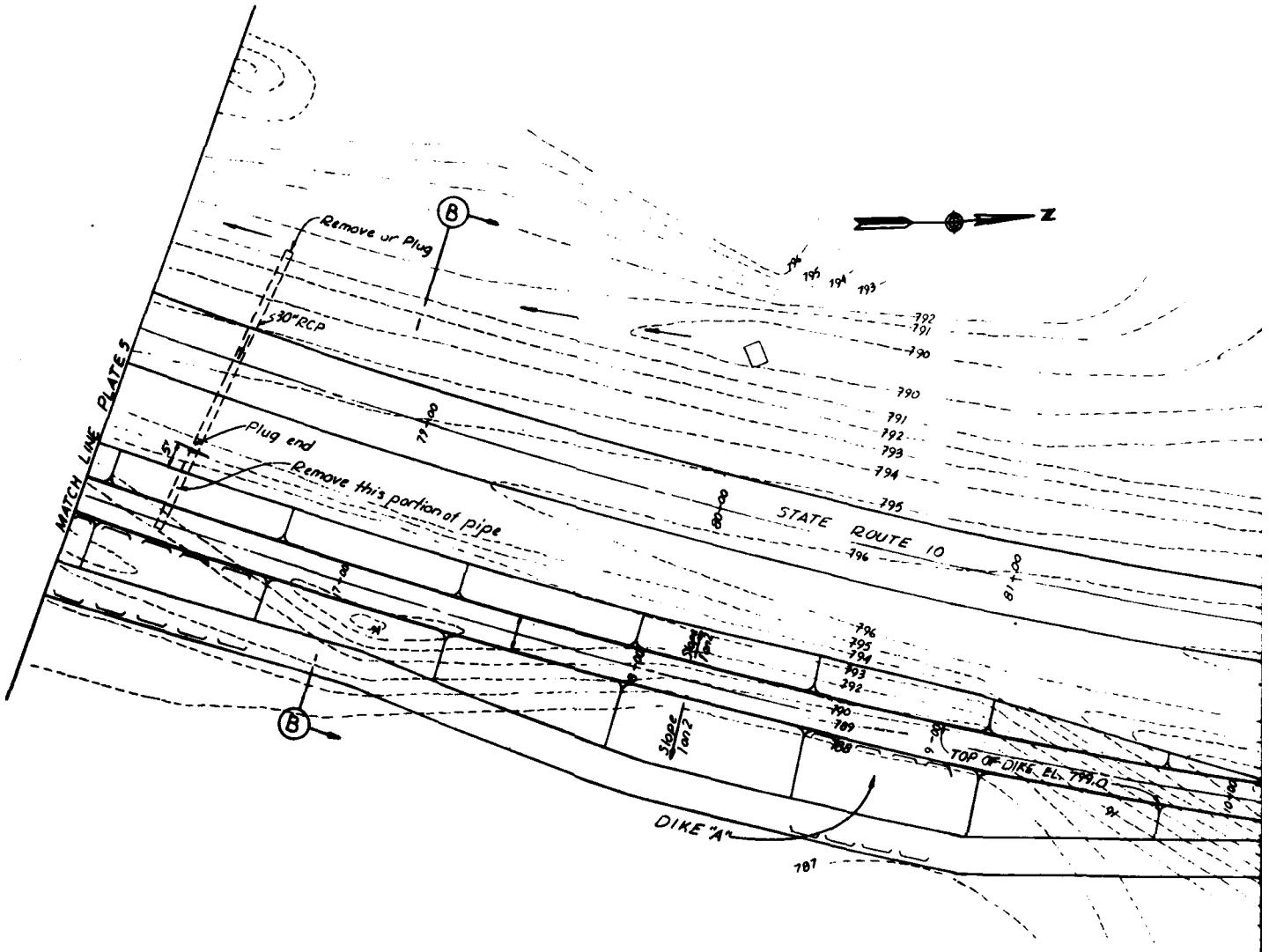
FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

DIKE "A" PLAN & SECTION NO. 1

PLATE 5

2




**PLAN**
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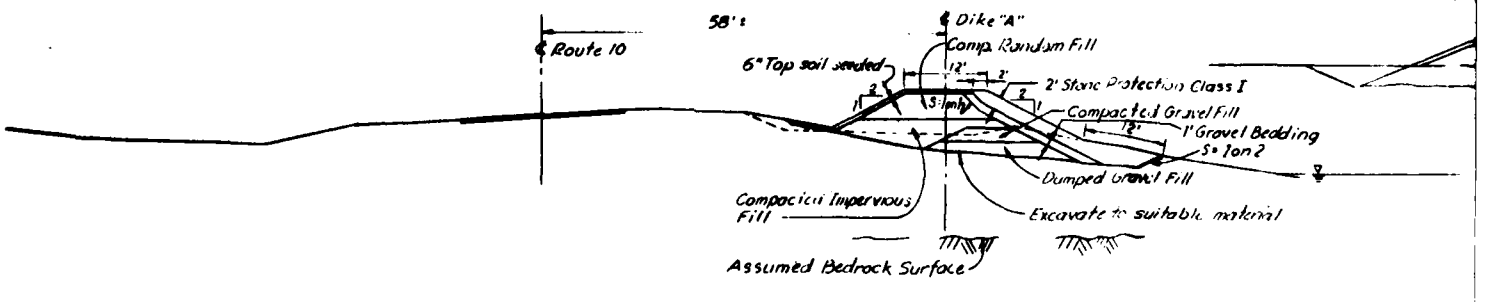
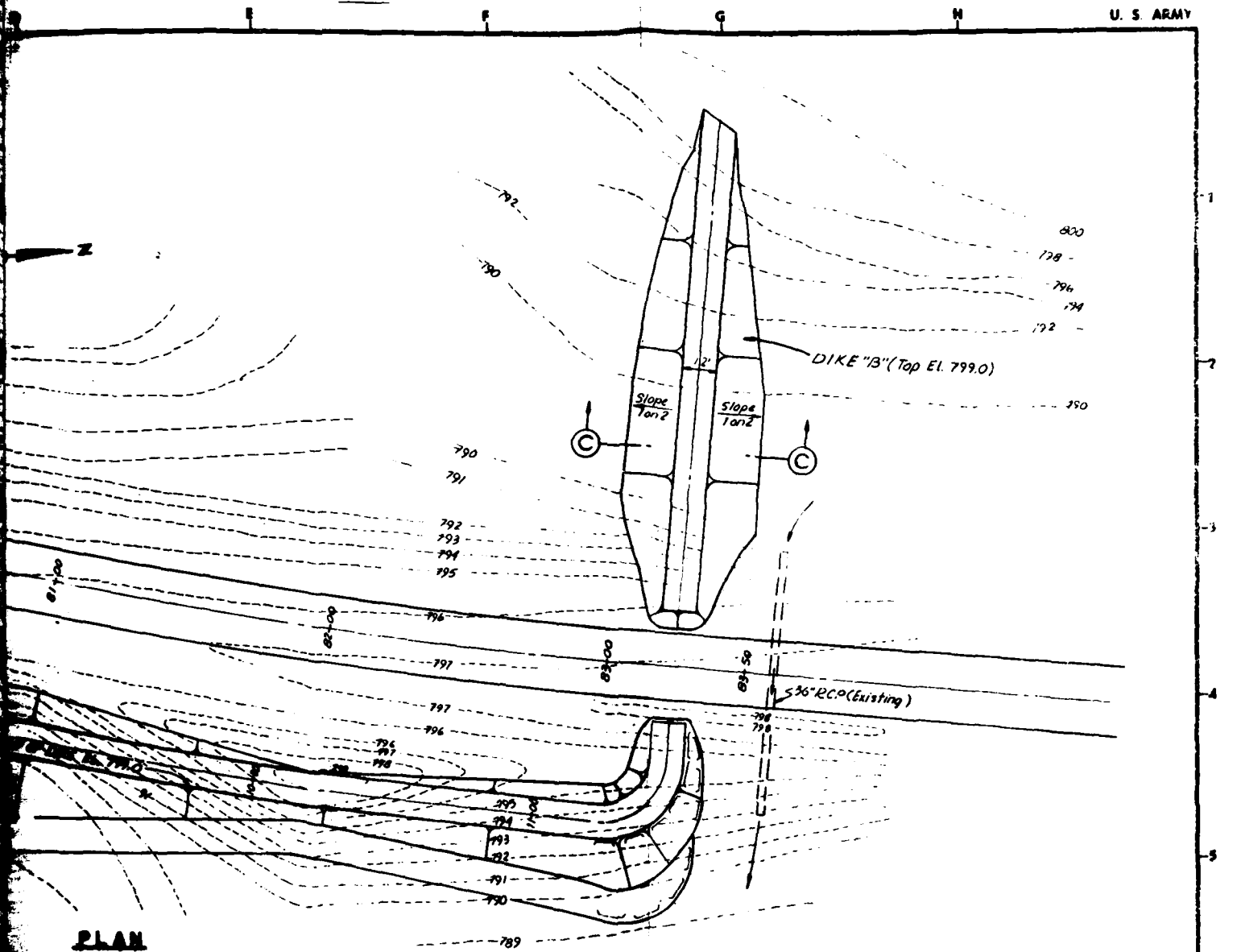
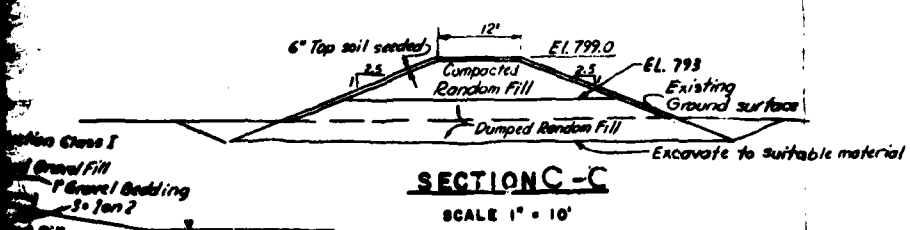
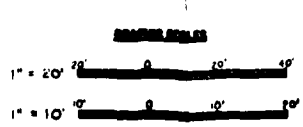



**SECTION B-B**
SCALE 1" = 10'




DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

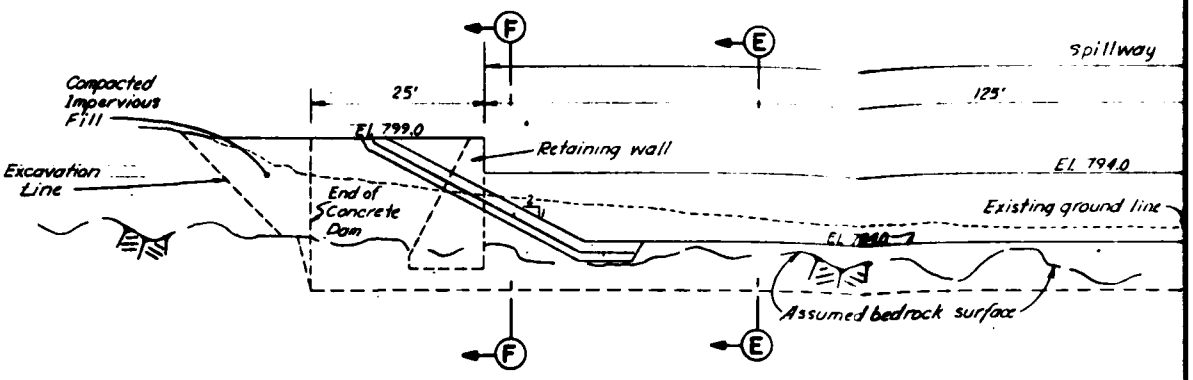
# FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

DIKE "A" PLAN & SECTION NO. 2

PLATE 6

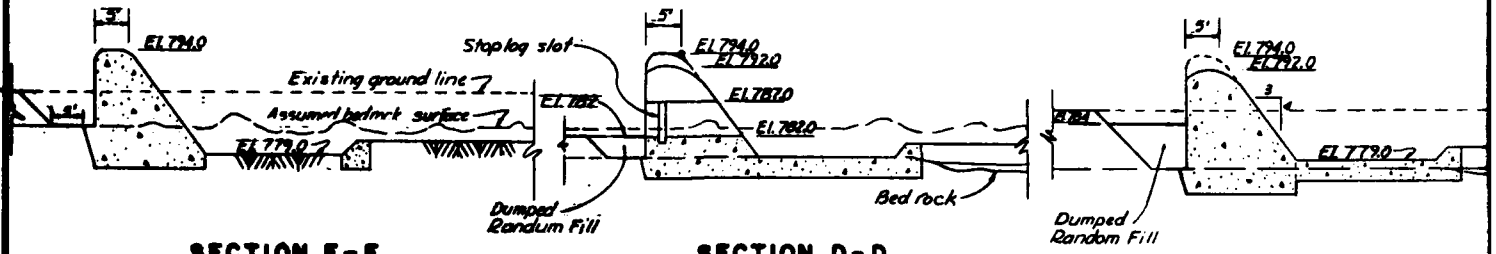
2




**DAM PROFIL**

(LOOKING DOWNST

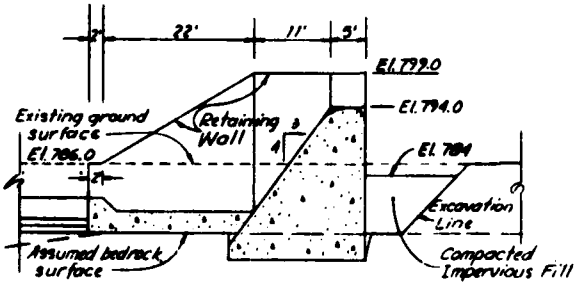
SCALE 1" = 10'



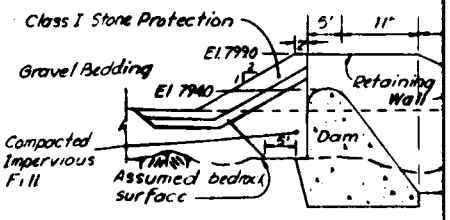

**SECTION E-E**

**SECTION D-D**

**SECTION C-C**

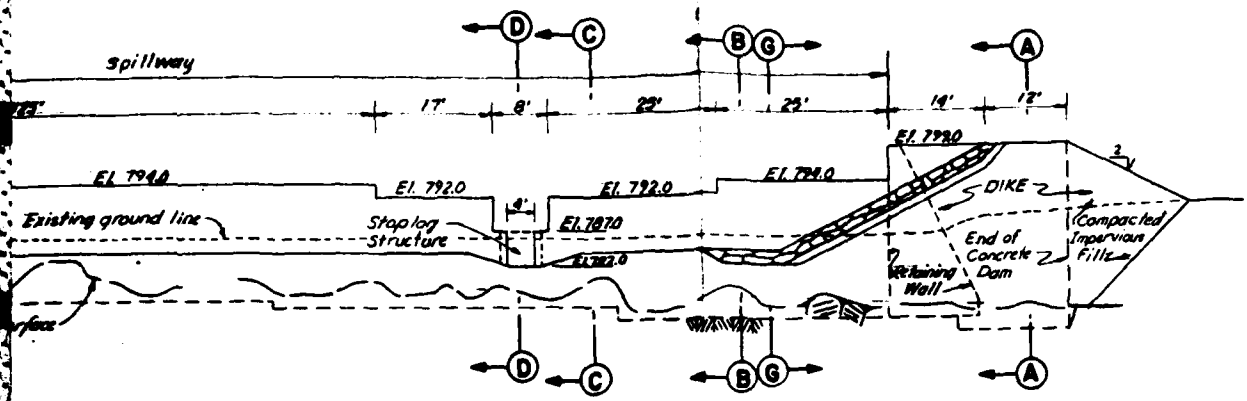



**SECTION G-G**

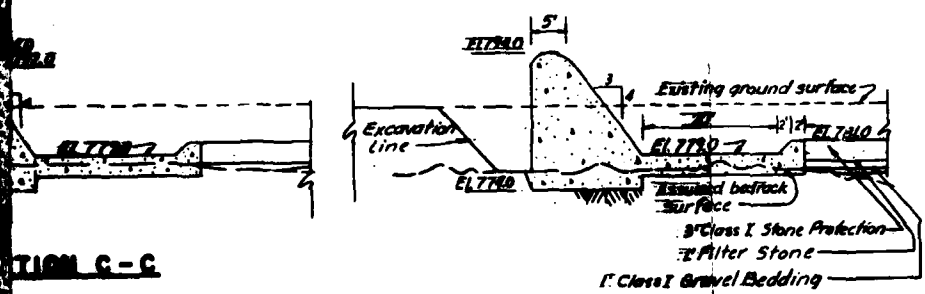



**SECTION**

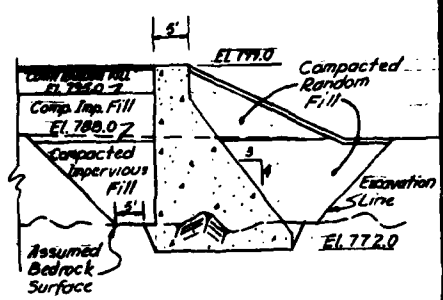
SECTIONS NOT TO



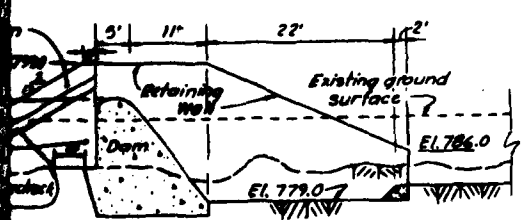

## DAM PROFILE
(LOOKING DOWNSTREAM)
SCALE 1" = 10'




## SECTION B-B




## SECTION A-A




## SECTION F-F

1" = 10'

SECTIONS NOT TO SCALE

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CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

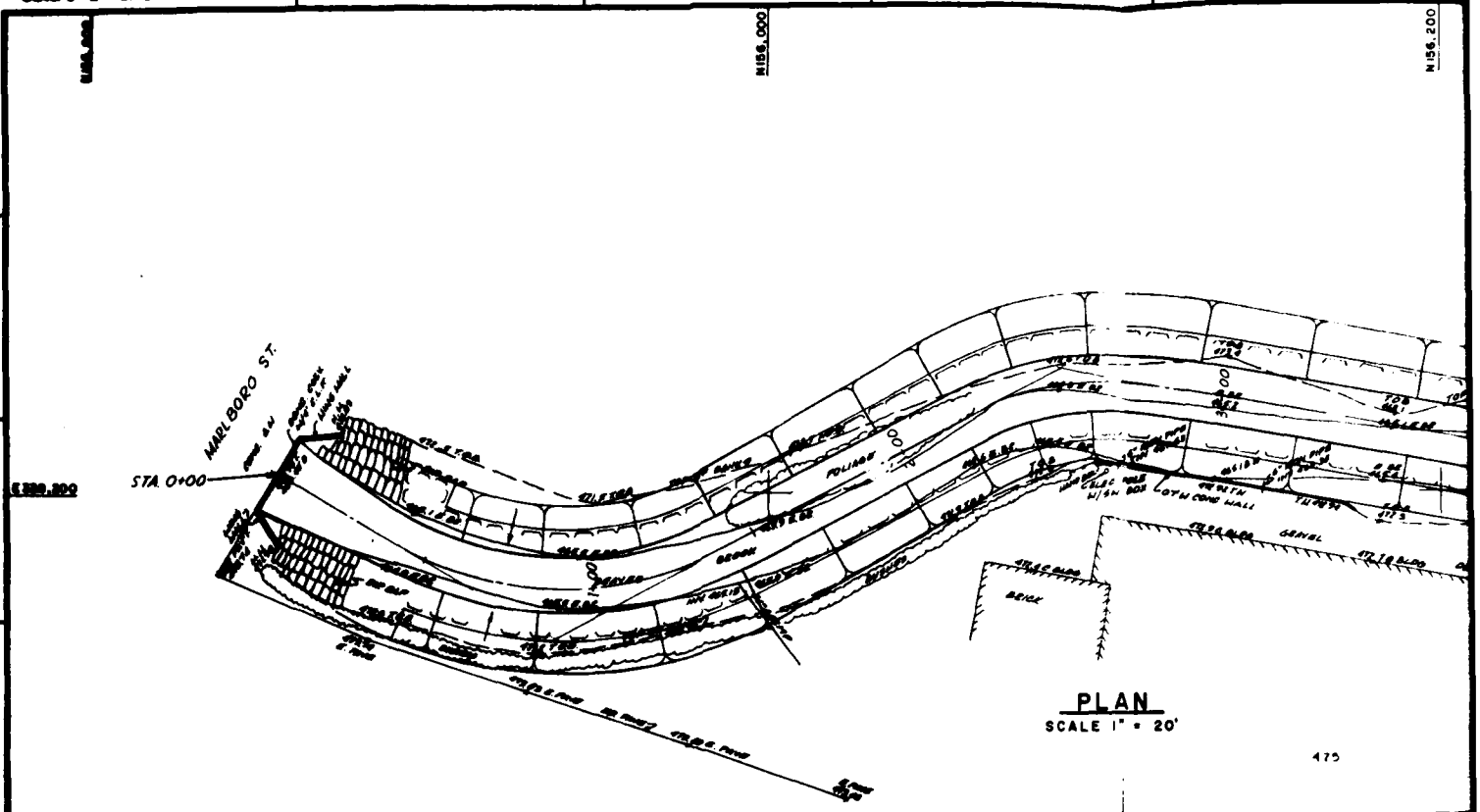
FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

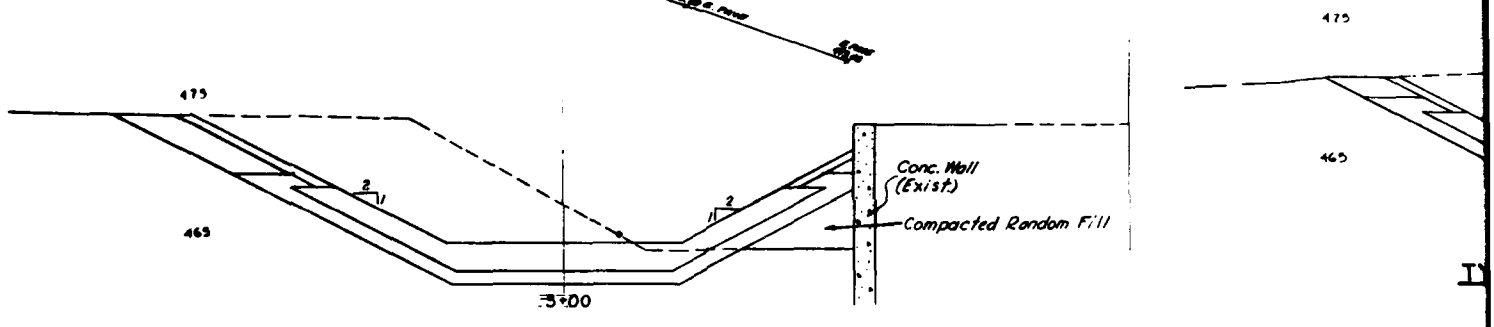
CONCRETE OUTLET SECTIONS

PLATE 7

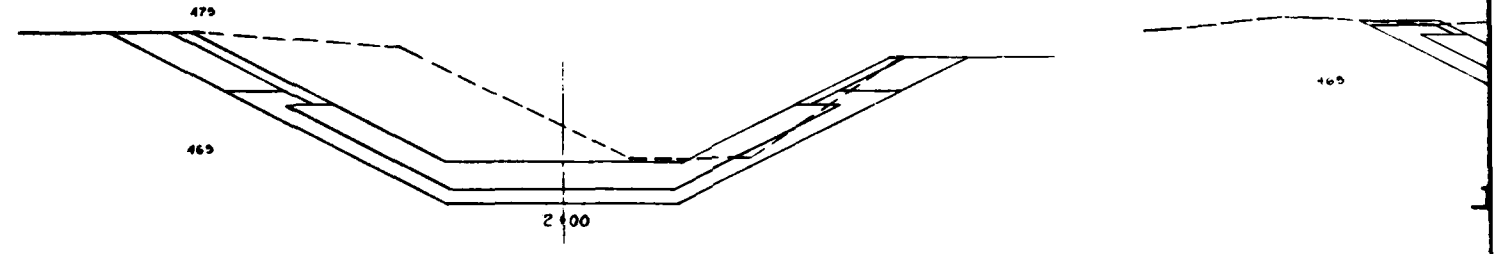
CORPS OF ENGINEERS



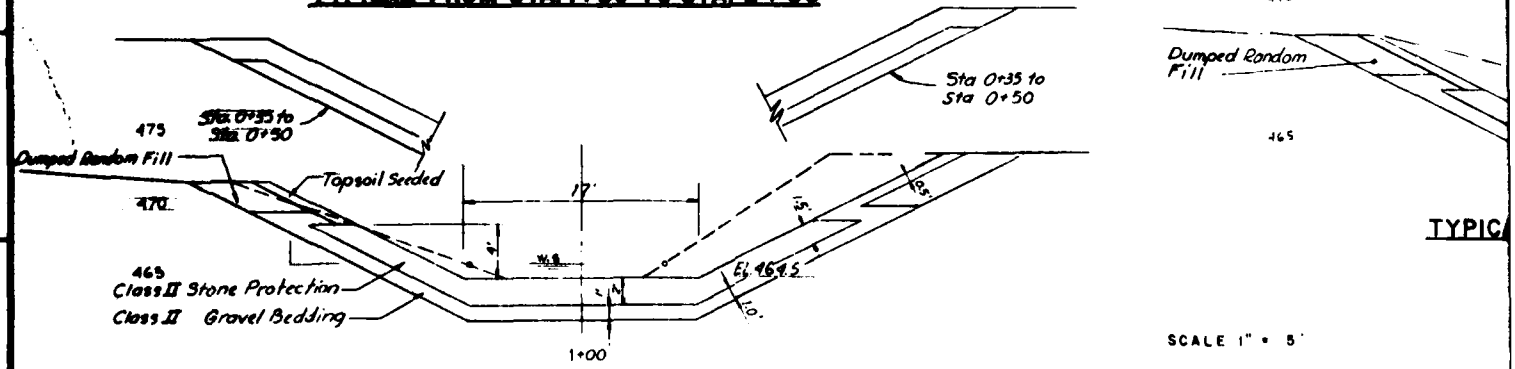

PLAN
SCALE 1" = 20'




TYPICAL FROM STA. 2+60 TO STA. 3+45

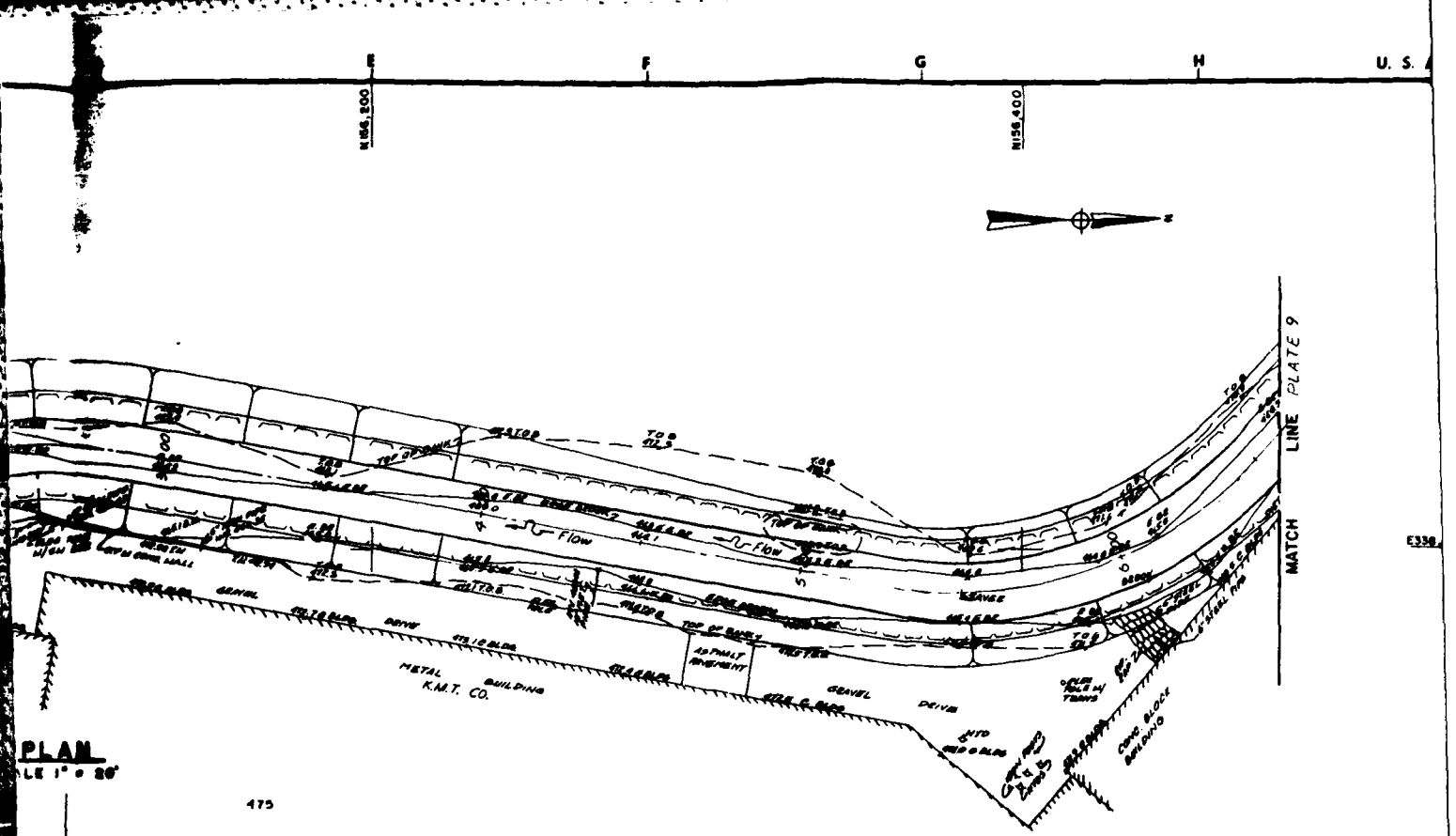



TYPICAL FROM STA. 1+50 TO STA. 2+60



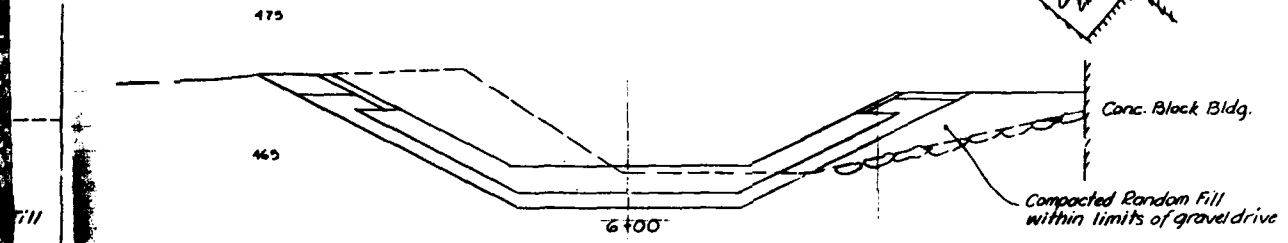

SCALE 1" = 5'

TYPICAL FROM STA. 0+35 TO STA. 1+50
MARLBORO STREET (STA. 0+00)

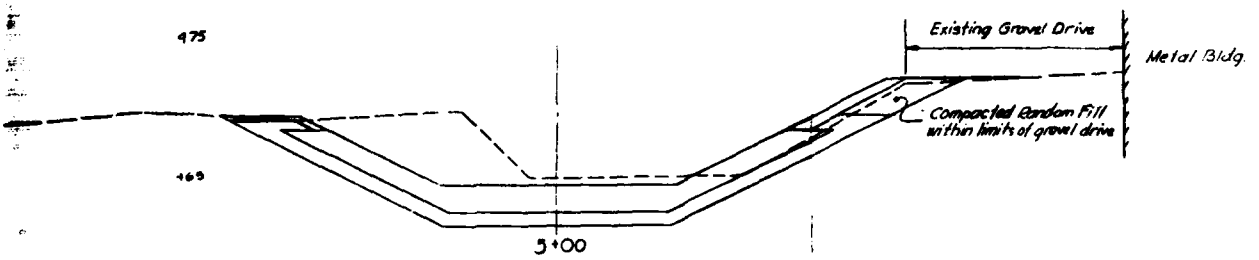



PLAN

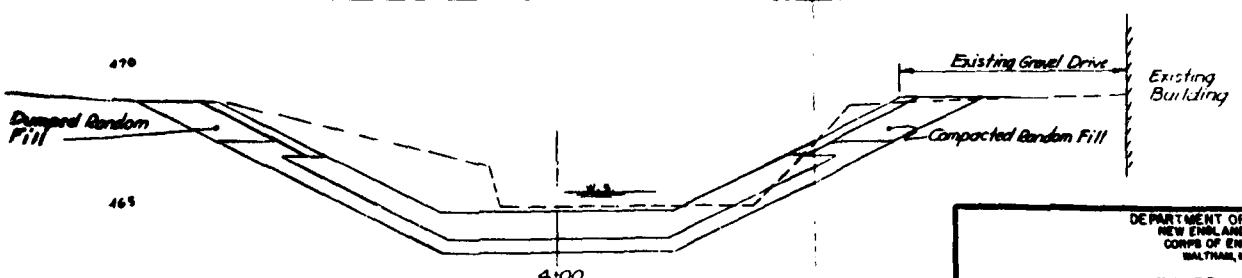
SCALE 1" = 20'



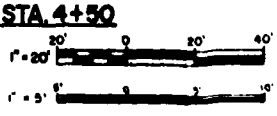

TYPICAL FROM STA. 5+50 TO STA. 6+58




TYPICAL FROM STA. 4+50 TO STA. 5+50




TYPICAL FROM STA. 3+45 TO STA. 4+50




SCALE 1" = 5'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

FLOOD DAMAGE REDUCTION

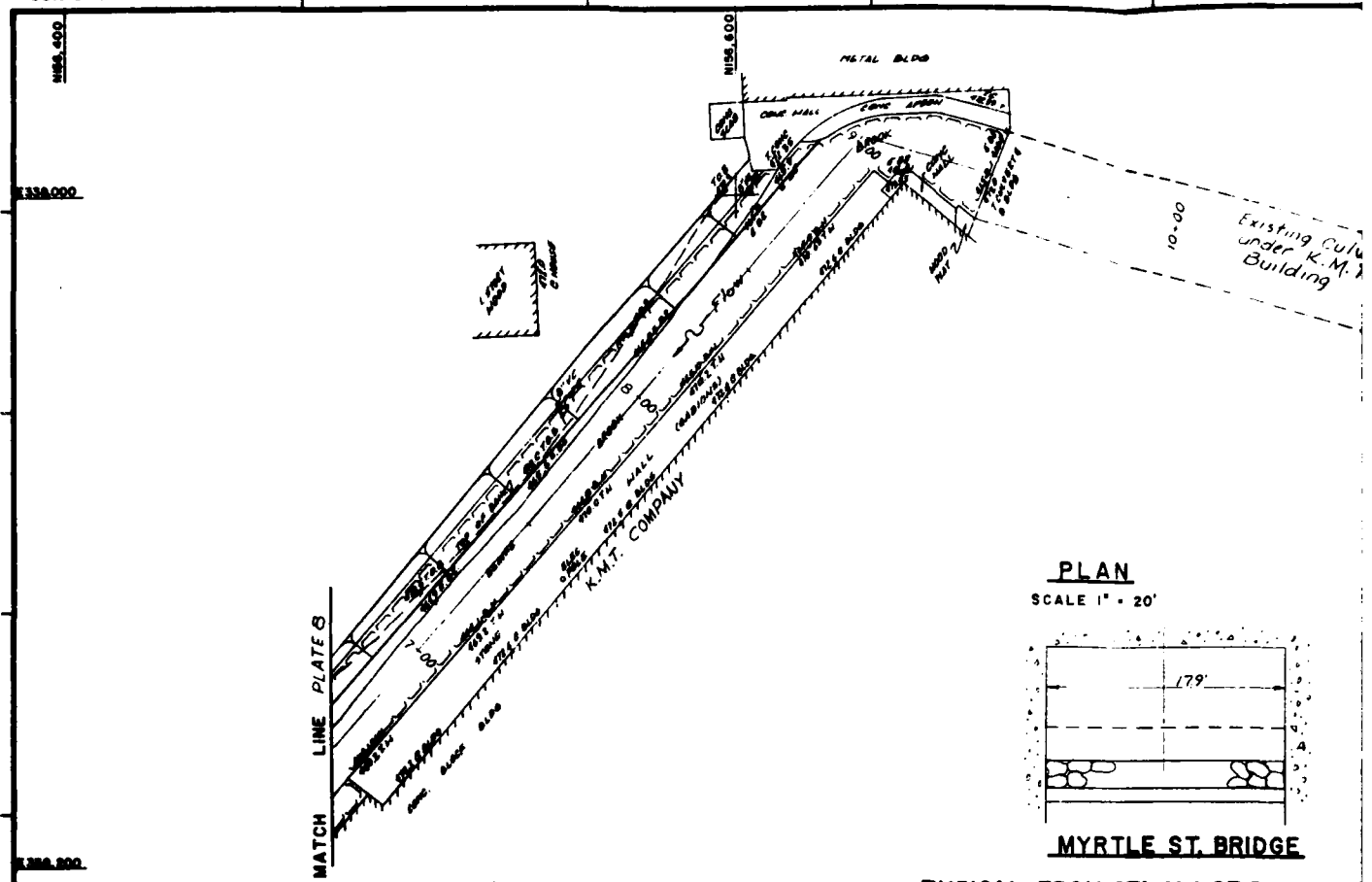
KEENE, NEW HAMPSHIRE

CHANNEL IMPROVEMENT
PLAN & SECTIONS NO. 1

PLATE

2

CORPS OF ENGINEERS



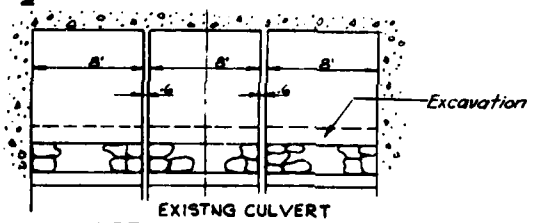

PLAN

SCALE 1" = 20'



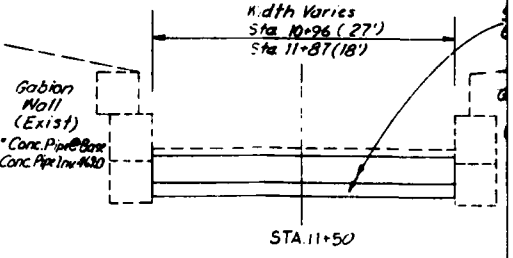

MYRTLE ST. BRIDGE

TYPICAL FROM STA. 11+87 TO STA. 12

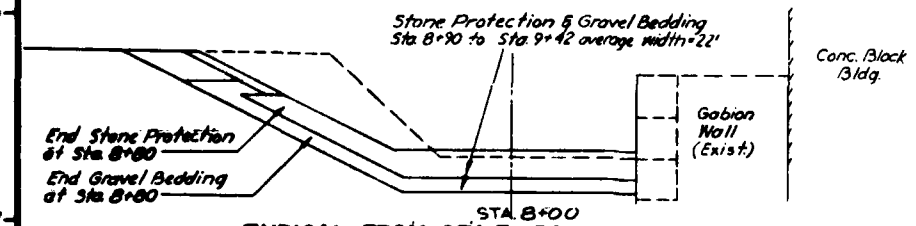



UNDER KMT BUILDING

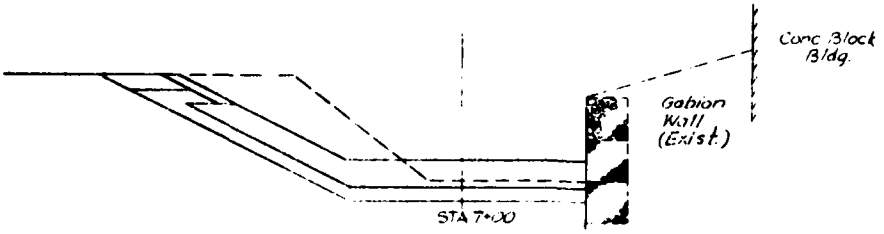
TYPICAL FROM STA. 9+42 TO STA. 10+96




TYPICAL FROM STA. 10+96 TO 11+87




TYPICAL FROM STA. 7+50 TO STA. 9+42




TYPICAL FROM STA. 6+58 TO STA. 7+50

SCALE 1" = 5'

E F G H U. S. ARMY

N 337,000

E 338,000

Existing Culvert under K.M.T. Building

Tank to be relocated

MATCH LINE PLATE 10

Sta. 13+14 to Sta. 13+64

Sta. 13+14 to Sta. 13+64

E 338,200

STA. 13+30

TYPICAL FROM STA. 12+75 TO STA. 13+64

Stone Protection and Gravel Bedding

Gabion Wall (Exist.)

Sta. 11+77 10" Conc. Pipe Inv 466.1

STA. 11+50

TO 11+87

Chain Link Fence

Parking

Compacted Random Fill within limits of Parking Lot

Sta. 12+18 12" conc. Inv 466.1 (To be relocated)

Sta. 12+02 to Sta. 12+52

Chain Link Fence

Parking

Rim El 474.12

M.H.

Inv 466.8

STA. 12+25

TYPICAL FROM STA. 12+02 TO 12+75

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

CHANNEL IMPROVEMENT
PLAN & SECTIONS NO. 2

PLATE 9

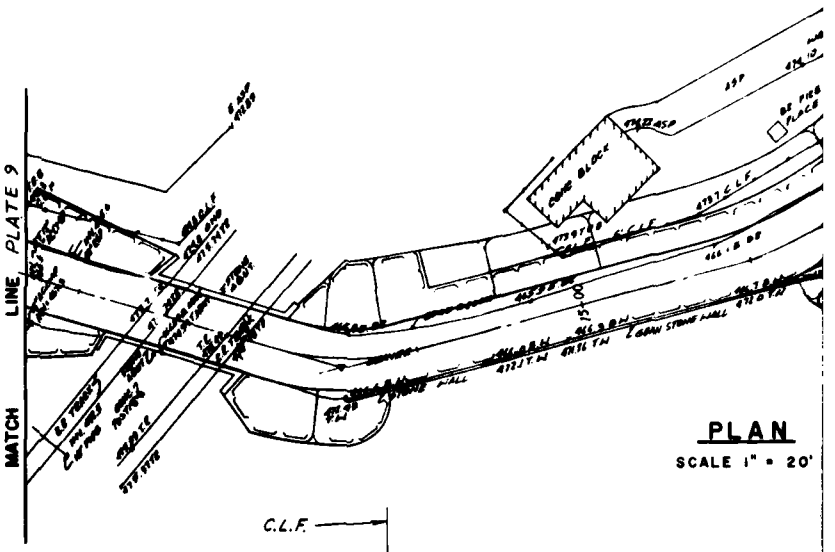
2

CORPS OF ENGINEERS

A B C D E

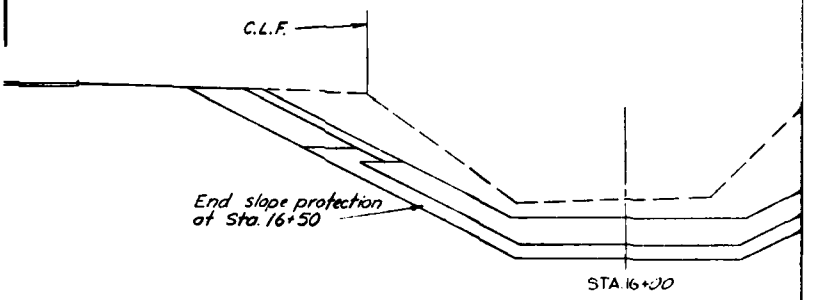
N 187,000 N 187,200

E 338,000

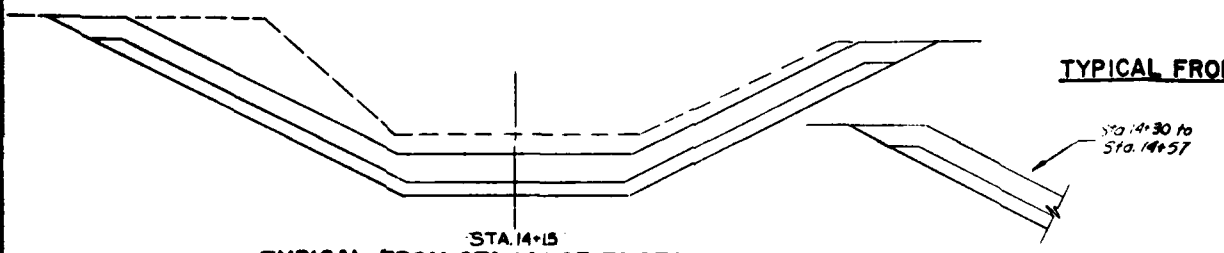



PLAN

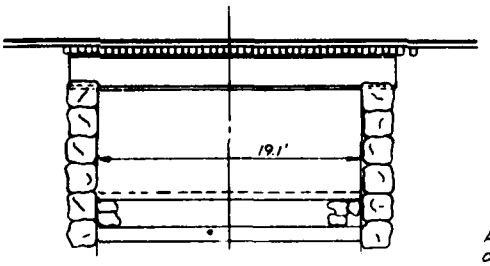
SCALE 1" = 20'




TYPICAL FROM STA. 15+70 TO STA

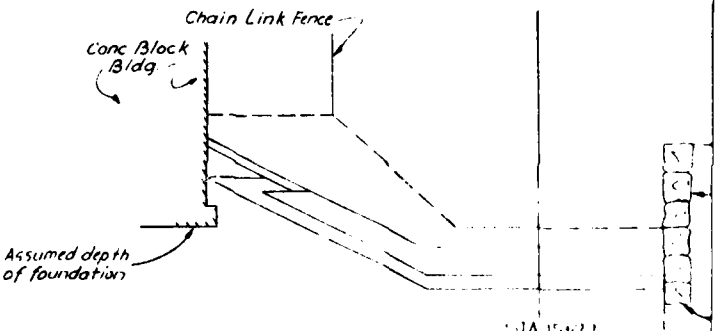



TYPICAL FROM STA. 14+07 TO STA. 14+30




RAIL ROAD BRIDGE

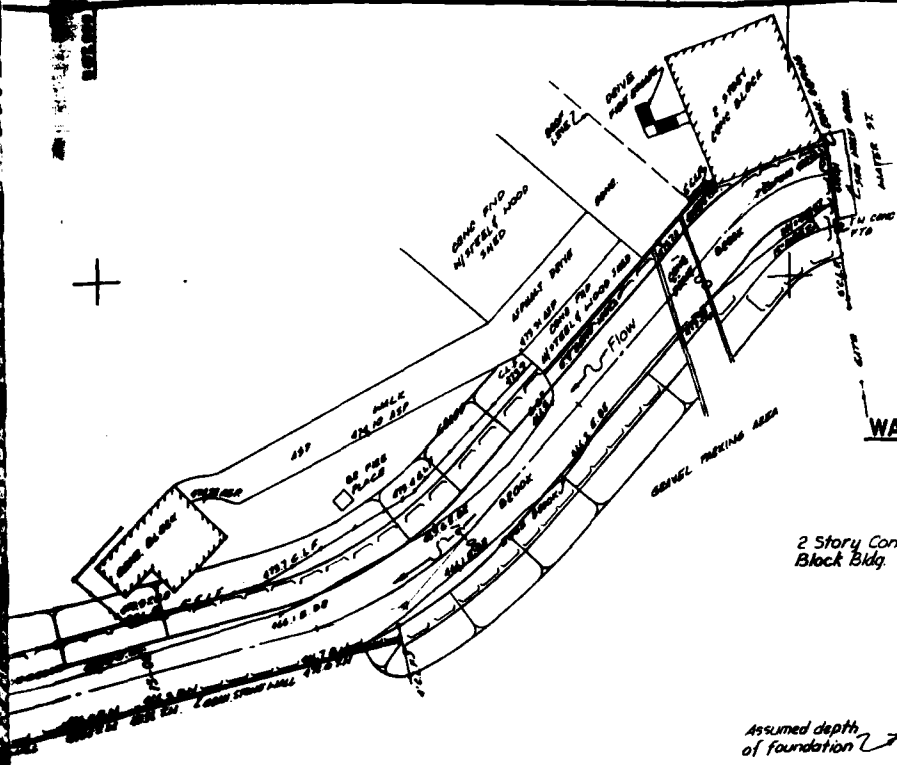
TYPICAL FROM STA. 13+64 TO STA. 14+07




TYPICAL FROM STA. 14+30 TO STA.

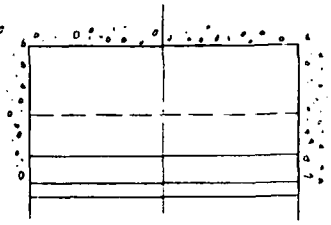
SCALE 1" = 5'

E F G H U. S. ARM

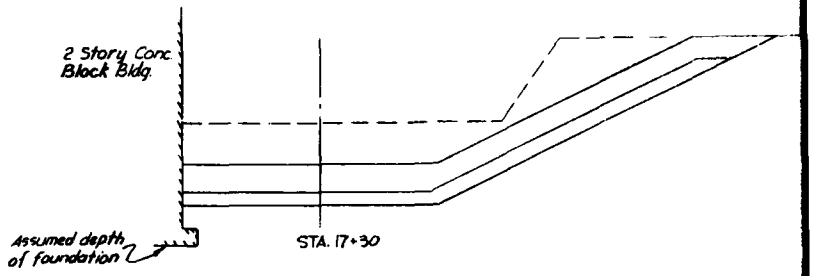



PLAN

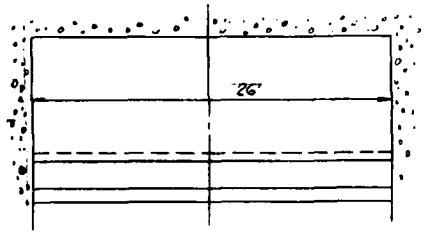
SCALE 1" = 20'



WATER ST. BRIDGE STA. 17+50

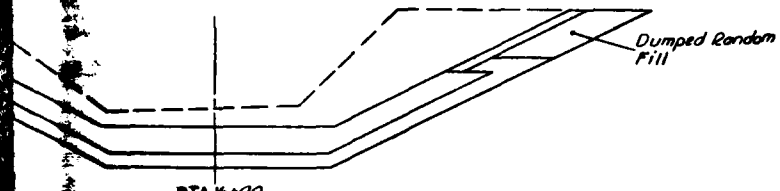



TYPICAL FROM STA. 17+04 TO STA. 17+50

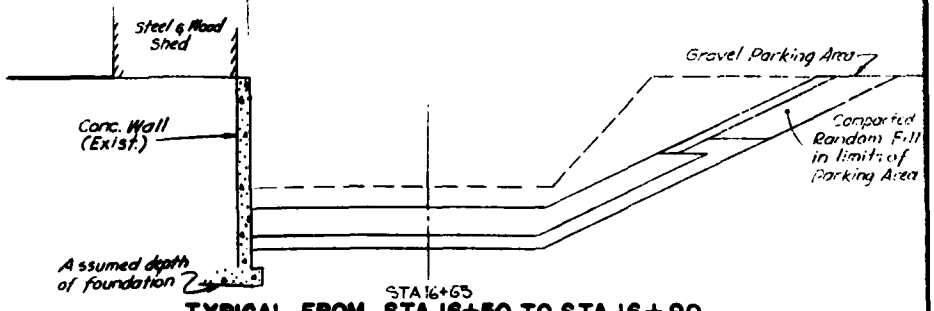



BRIDGE SO. OF WATER ST.

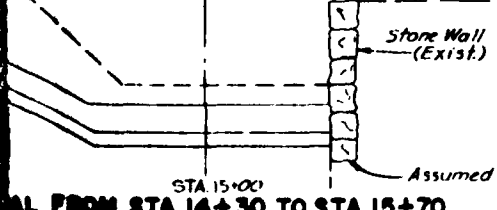
TYPICAL FROM STA. 16+90 TO STA. 17+04




ICAL FROM STA. 15+70 TO STA. 16+50

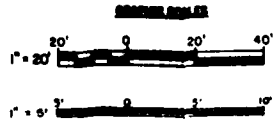



TYPICAL FROM STA. 16+50 TO STA. 16+90




AL FROM STA. 14+30 TO STA. 15+70

SCALE 1" = 5'




DEPARTMENT OF THE ARMY
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CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

CHANNEL IMPROVEMENT
PLAN & SECTIONS NO 3

PLATE 1

2

storage, and would not be affected at all by the channel improvements. Therefore, residents of the Keene flood plain should still be aware that the risk of major flooding along Beaver Brook would remain.

Other long term impacts of Plan A would include those permanent environmental impacts related to the character and configuration of the proposed project features. The construction of the new outlet structure at the Three Mile Swamp would involve the loss of the existing stone wall dam and of the approximate 3/4 acre of wooded habitat downstream of the dam, where the stilling basin and tailrace channel would be located. The loss of this wooded habitat is not expected to have a significant effect on regional mammal and bird populations since this habitat is available elsewhere in the area. However it would expose the proposed outlet structure to the roadway, entirely changing the present scenic character along this reach of Route 10.

Replacement of the dam itself would not alter the existing wetland habitat around Three Mile Swamp, and in fact would lend greater stability to this area through the fee acquisition of the wetland property. Since the proposed invert elevation of the outlet structure would remain at elevation 787 ft. NGVD, the existing pool elevation of the swamp would be preserved. However, during flood periods the pool elevation would rise higher under the modified condition, and would remain at that higher elevation for a longer period of time. The extreme case would be during an SPF event when the pool level would rise about 4 feet higher than under existing conditions, and would take an extra 24 hour period to drain back to its normal level. In total, the SPF would inundate up to 120 acres of land on a temporary basis.

Additional environmental impacts would result from the construction of the dike along Rte 10, where the streamside toe of the dike would displace a half acre of wetland habitat. The loss of this habitat is not expected to have a significant impact on resident populations since a half acre represents less than two percent of the total wetland acreage. In addition, the habitat displaced by the dike would mostly be at the perimeter of the wetland, and since the Three Mile Swamp is long and narrow, there are over 2 miles of perimeter habitat in this wetland. A Section 404 Evaluation of the impacts of placing fill below the waterline of Beaver Brook has been accomplished, and is presented in conjunction with the environmental assessment.

Perhaps a more significant impact related to the dike would be the disruption of the view of the wetland from the Route 10 roadway. Since the grade of the roadway rises from elevation 792 feet NGVD at the dam to elevation 797 feet NGVD 1100 feet upstream of the dam, the effect of the dike on the view would lessen as one proceeds upstream. With a top elevation of 799 feet NGVD, the top of the dike would be seven feet above the road surface at the dam, obstructing all view of the wetland at that

point. However, within 600 feet upstream of the dam the top of the dike would only be four feet above the roadway, and a partial view of the wetland could be obtained at that point. Some of this impact would be eased by planting the roadside face of the dike with grasses instead of layering it with gravel protection. Since the dike does not extend beyond the point where the old road bed leaves Route 10, access to the swamp for anglers and canoeists would not be disturbed.

Finally, long term environmental impacts resulting from the downstream channel improvements are not expected to be significant. Widening the channel would involve the clearing of vegetation along the west (right) bank of the river at the end of Gardner Street, but this could be mitigated by planting shrubs and bushes along the top of the bank. Additional loss of vegetation would occur as a result of the streambanks being layered with stone slope protection. The extent of this impact would be limited to the lower channel, however, since the top 3 feet of the banks would be covered with topsoil and seeded. The channel invert would also be layered with stone protection and would continue to silt in as it does now. For the same reasons, the city of Keene would have to continue a program of channel maintenance along this reach to periodically remove silt buildup encroaching on the channel capacity.

Economics- Table 8 summarizes the economic analysis of Plan A, which would have a total first cost of $1,641,000. Annual costs, determined by amortizing the investment cost of the project over a 100-year period (at current interest rates of 7-7/8 percent for Federal Water Resources Projects) would total $135,800, including operation and maintenance costs. The estimated annual flood control benefit of Plan A is $234,200, giving the plan a favorable benefit-cost ratio of 1.7 to 1.0.

Table 8 also presents the division of cost responsibilities between the Federal Government and the Non-Federal sponsor. Cost sharing between Federal and non-Federal interests is established by Section 3 of the 1936 Flood Control Act, whereby non-Federal interests would be required to provide lands and easements for the project, pay for utility relocations, and agree to maintain the project after it is constructed. As the sponsor of the project, the city of Keene would have to provide project lands and easements, estimated to total $159,000, pay for the relocation of utilities, estimated at $10,000, and maintain and operate the project after construction, at an estimated annual cost of $1,500.

TABLE 8
ESTIMATE OF FIRST COSTS AND ANNUAL CHARGES
PLAN A

| | |
|---|---|
| **FIRST COST** | |
| Construction Cost - | |
| 3-Mile Swamp | $997,900 |
| Channel Improvements | 223,700 |
| Engineering and Design | 132,000 |
| Supervision and Administration | 128,400 |
| Lands and Easements | 159,000 |
| TOTAL FIRST COST | $1,641,000 |
| Federal Share | 1,472,000 |
| Non-Federal Share | 169,000 |
| Total Investment | |
| First Cost & Interest During Construction | $1,704,300 |
| **ANNUAL COST** | |
| Interest and Amortization | $134,300 |
| Operation and Maintenance | 1,500 |
| TOTAL ANNUAL COST | $135,800 |
| Federal Share | $120,500 |
| Non-Federal Share | $15,300 |
| **PROJECT JUSTIFICATION** | |
| Annual Benefit | $234,200 |
| Benefit-Cost Ratio | 1.7 to 1.0 |

Plan B - Nonstructural Alternative

Description- Plan B has been developed to provide a minimum amount of protection to flood-prone residents with the least disturbance to the existing conditions of the Beaver Brook watershed. It proposes the installation of an automated warning system within the Beaver Brook watershed to provide flood plain residents with timely and accurate forecasts of potential flooding along Beaver Brook. With sufficient warning time, it is expected that the risk to human safety can be greatly reduced and that perhaps some property losses can be avoided if belongings are elevated above the flood level. It should be noted that this proposal only provides for the installation and programming of equipment necessary to provide a warning capability to the city, including predictions of peak flood stage. With implementation of this plan, it would be the city of Keene's responsibility to set up a communication and evacuation plan with which to disseminate warning information.

Keene residents of the Beaver Brook basin would be served by a system of 2 precipitation gages, a temperature gage and a stream gage in consort with a microcomputer equipped to transmit and receive data and messages. The two rain gages, including one with a temperature gage, would be installed in the upper Beaver Brook watershed, and would relay information regarding type and amount of precipitation to the microcomputer. The stream gage would be located downstream of George Street, near where the river converges on the flood plain, and would automatically respond to changes in streamflow with a report back to the computer. Typical cross sections of an automated river gage and rain gage are presented on Plates 11 and 12 respectively. The microcomputer would be located at the city's flood forecasting center. Based on flood flow models developed for the Beaver Brook basin, and on the hydrologic data gathered from the gages, the microcomputer would be capable of estimating expected peak flood stages for Beaver Brook. When flooding became imminent, the microcomputer would print out a warning, light a warning signal, and sound an audible alarm. The microcomputer would also be capable of transmitting data and messages to the National Weather Service's (NWS) central computer in Bloomfield, Connecticut.

The location of the flood forecasting center must be chosen with the following criteria in mind:

a) it must be staffed and operational on a 24-hour basis
b) it should have an adequate communications ability
c) it should be located outside of the flood plain and
d) it should have an auxiliary power supply.

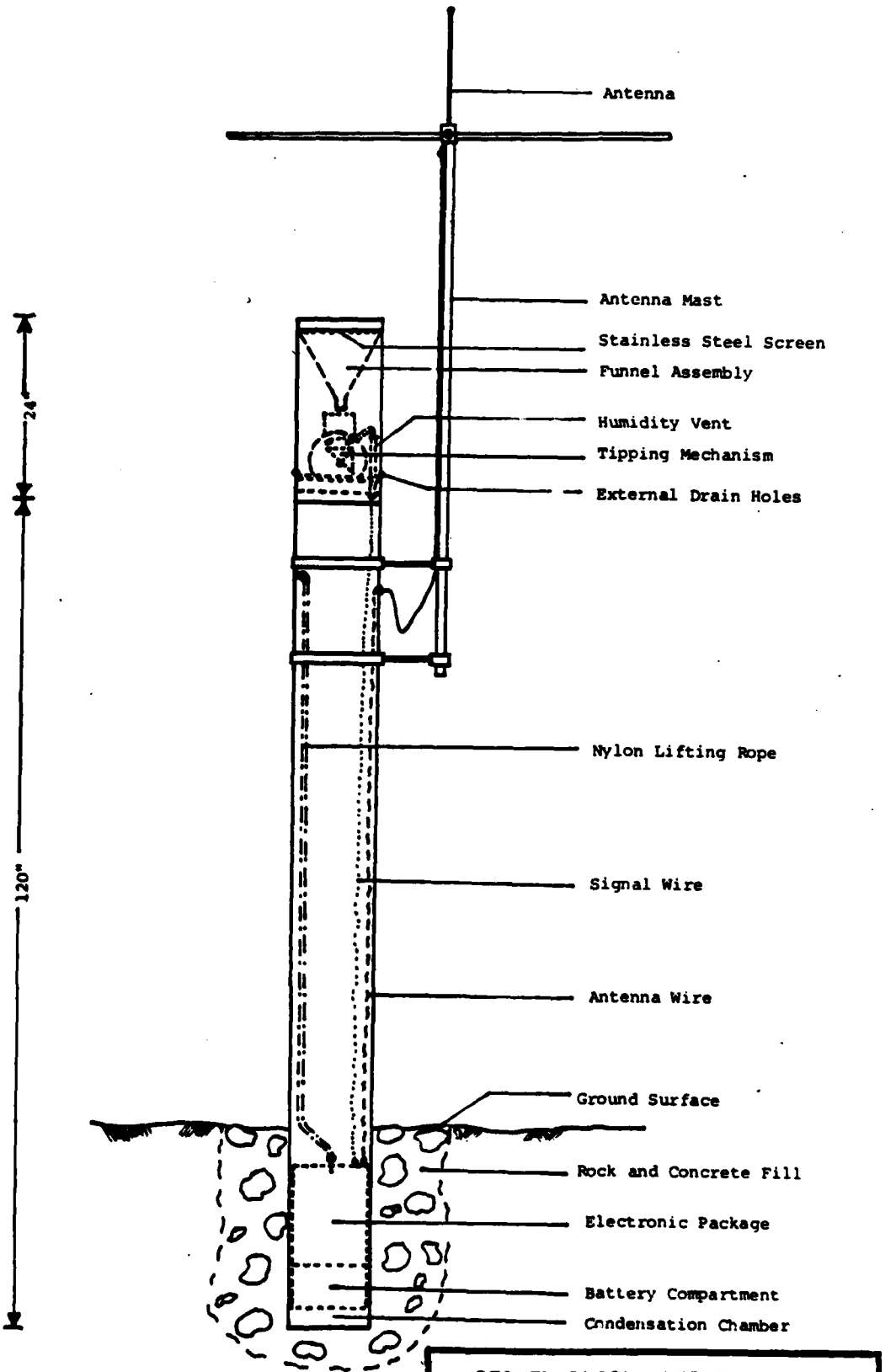
Based on conversations with Keene officials, the tentative site for the forecasting center would be the public works building, located on Main Street.

Tentative locations for precipitation and stream gages were also designated with assistance from NWS. These sites were chosen after consideration of several factors governing their location. First, the gages must be installed at locations which provide important hydrologic information representative of the basin. Because field equipment requires annual maintenance, accessibility is also important. Finally, efforts should be made to reduce the risk of vandalism to the equipment.

The following two sites have tentatively been selected for the location of precipitation gages.

1) Drummer Hill
2) Sullivan Center Road near the Gilsum Town Line.

A tentative location for the stream gage is in the upper reach of the Woodland Cemetery, downstream of George Street, where a streamgage was once maintained by the Corps.

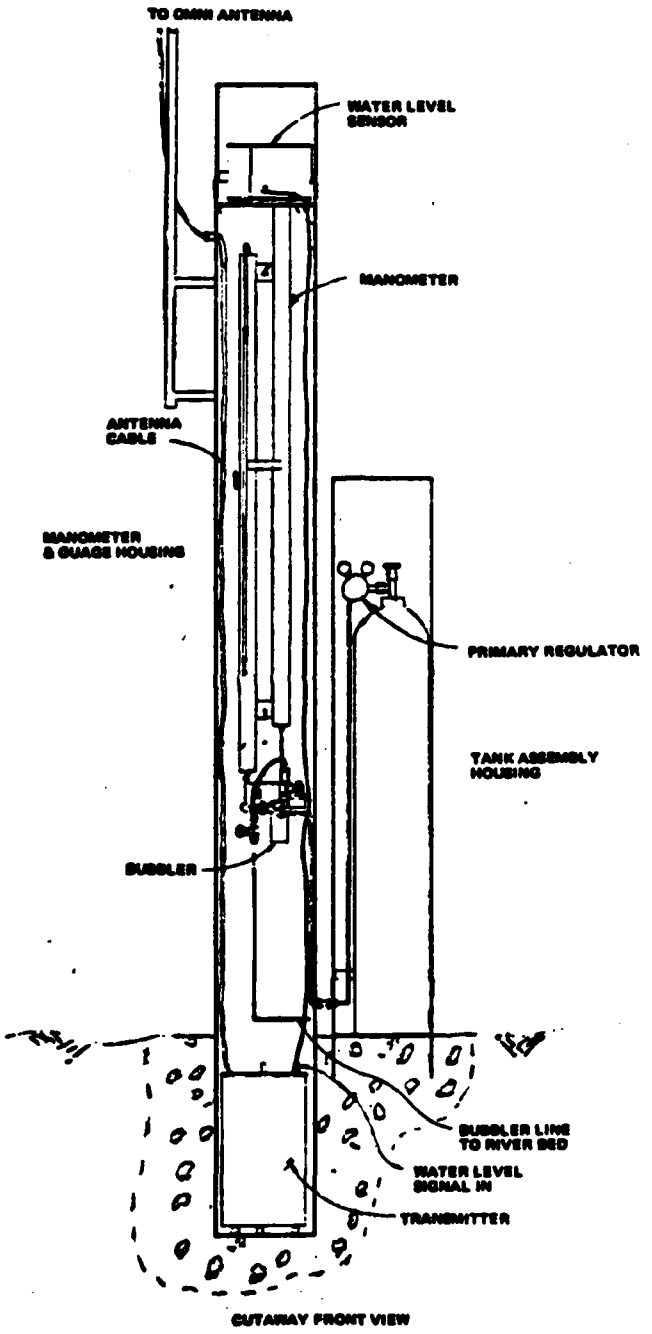



BEAVER BROOK, KEENE, N.H.

TYPICAL SECTION

Reporting Precipitation Gage

PLATE 11




BEAVER BROOK, KEENE, N.H.

TYPICAL SECTION

Reporting Stream Gage

PLATE 12

The above system is designed to be fully automated and would essentially operate unattended around the clock. The exception to this would be at the streamgage, where icing problems would be encountered. The city of Keene would have to maintain the gage free of the ice to insure accurate streamflow readings. When flooding is imminent, the microcomputer prints a warning and initiates audible and visual alarms. Round the clock monitoring of the microcomputer would be essential to insure that the message of warning was received by flood plain residents.

The field equipment developed for automated warning systems has been engineered to provide dependable service at a low operation and maintenance cost. Stream and precipitation gages operate on a battery power supply that must be replaced annually. An antifreeze solution contained in the precipitation gages also needs to be changed yearly. Electronic maintenance of all equipment would be required once every three years to adjust the the frequency of the transmission signal, and the National Weather Service would periodically update the streamflow models to reflect the hydrologic data acquired over years of operation. Finally, because the flood warning equipment has a design life of approximately 10 years, the replacement of this equipment would be the city of Keene's responsibility as the local sponsor of the project.

Impacts- Implementation of Plan B would involve very little construction and hence very few impacts to the environment. The major short-term impact would result from the initial set-up of the warning system, when a reliable evacuation plan would have to be developed and repeatedly practised by the community to insure that the full benefit of the warning system could be obtained.

Once in effect, the warning and evacuation plan would give residents an indication of the depth of flooding expected, and give them warning to secure their property. The warning system would also help minimize the threat to health and safety posed by a flood, by alerting citizens of any need to evacuate the floodplain. Although this plan would not reduce floodstages, it would relieve considerable tension and anxiety of floodplain residents by taking the guess work out of flood forecasting. By providing residents with about 2 hours of warning time to secure their property, Plan B would reduce estimated flood losses by as much as $10,000 annually.

The long term effectiveness of Plan B would depend largely on the maintenance of the flood forecasting equipment and on the education of the affected public through periodic testing of the emergency action plan. Without a continued effort in these areas, the effectiveness of this plan would decrease with time.

Economics- When analyzing the economics of this plan, only the benefits derived from reducing flood damages were evaluated. Intangible benefits such as increased protection to the life and safety of flood plain residents were not included.

Inundation reduction benefits are measured as the reduction in the amount of flood damages and related costs that would have occurred without any

plan of protection. Because floodwaters are not restricted under Plan B, the majority of these benefits would result from flood plain occupants moving damageable property above expected flood levels. However, occupants of the flood plain will respond to the flood warning with different levels of efficiency. Determining the amount of damageable property residents will remove would be virtually impossible without assuming that flood plain occupants would react in a rational manner and voluntarily undertake certain actions to reduce flood damages. This assumption will become more realistic as more people become informed of the flood preparedness plan.

Damage survey sheets were evaluated in order to determine the degree of losses that could be prevented. The analysis shows that damages to potentially movable items consist of equipment, stock, furnishings, appliances and similar contents. With an early flood warning system, the amount of time available for moving contents would vary from about 1 to 3 hours. Given this time constraint, it is very unlikely that all potentially movable items could actually be relocated. The lack of time would prohibit the mobilization of sufficient manpower, moving equipment, and storage space. The impracticality of transporting large cumbersome machinery would also pose problems. Analysis of the damage information reveals that because of the logistical considerations discussed above, only about half of the damages to movable contents could actually be prevented with the warning plan. Benefits of the warning plan were therefore estimated to total $10,000 annually. Table 9 summarizes the economic analysis of Plan B, which would have an estimated first cost of $30,300. When the annual benefits of $10,000 are compared with annual costs of $5,300, the resulting benefit-cost ratio is 1.9 to 1.0.

Because of the limited scope of this plan, the responsibility for its implementation would rest with the city of Keene. The Corps would provide construction guidance, and could act as a liasion between Keene and the NWS. The NWS would assist the city of Keene by providing the necessary software and forecast advisory services, assisting in the location of field equipment and training personnel in the use of the base station equipment.

TABLE 9
ESTIMATE OF FIRST COSTS AND ANNUAL CHARGES
PLAN B

| | |
|---|---|
| **FIRST COST** | |
| Construction Cost | $24,500 |
| Engineering and Design | 3,000 |
| Supervision and Administration | 2,800 |
| TOTAL FIRST COST | $30,300 |
| | |
| Federal Share | - |
| Non-Federal Share | $30,300 |
| | |
| Total Investment | |
| First Cost & Interest During Construction | $30,600 |

ANNUAL COST

| | |
|---|---|
| Interest and Amortization | $2,400 |
| Operation and Maintenance | 800 |
| Funding for Periodic Equipment Replacement | $2,100 |
| TOTAL ANNUAL COST | $5,300 |
| Federal Share | - |
| Non-Federal Share | $5,300 |

PROJECT JUSTIFICATION

| | |
|---|---|
| Annual Benefit | $10,000 |
| Benefit-Cost Ratio | 1.9 to 1.0 |

Plan C - Combination Alternative

Description- The third alternative is a plan combining the structural and nonstructural measures of the two previously described plans, designed to maximize the potential benefits available from a flood protection plan along Beaver Brook. Since the structural alternative is only effective in reducing stages during smaller, more frequent events, it was felt that an automated warning plan would still be valuable to flood plain residents during rarer floods. Plan C, therefore, includes three elements, each described in detail in Plans A and B, and summarized as follows:

1) Modification of the outlet structure at Three Mile Swamp to better utilize the existing storage capacity of the wetland;

2) Construction of channel improvements in the 1750-foot reach of Beaver Brook between Water Street and Marlboro Street; and

3) Installation of an automated flood forecast and warning system composed of 2 automatic precipitation gages, a temperature gage, an automated stream gage, and a microcomputer with alarm-sounding capability.

Impacts- Impacts resulting from implementation of Plan C would basically be a combination of all of the impacts presented for Plans A & B. It is still important to note that the effect of Plan C on flood flows would be the same as Plan A, and that the risk of major flooding on Beaver Brook would not be altered. This plan would only reduce flood stages associated with the more frequent flood events on Beaver Brook, providing protection against the 10-20 year flood.

Economics- For the purposes of incremental justification, it was assumed that the automated warning plan would act after the two structural components, since flood stages would be lowered by these elements, requiring the removal of fewer property items. Under this analysis, the flood warning plan would provide an average flood damage reduction of $5,500 annually. Table 10 presents the economic analysis for Plan C,

which would have a first cost of $1,671,300 and annual costs of $141,100. When compared with total estimated benefits of $239,700, Plan C would have a benefit-cost ratio of 1.7 to 1.0.

Proposed cost-sharing between Federal and non-Federal interests for Plan C would be as shown in Table 10. The entire project would be transferred to the city of Keene following the completion of construction, after which time the city of Keene would be responsible for project maintenance. Maintenance and equipment replacement costs are estimated to total $4,500 annually.

TABLE 10
ESTIMATE OF FIRST COSTS AND ANNUAL CHARGES
PLAN C

| | |
|---|---|
| **FIRST COST** | |
| Construction Cost | |
| 3-Mile Swamp | $997,900 |
| Channel Improvements | 223,700 |
| Warning System | 24,500 |
| Engineering and Design | 135,000 |
| Supervision and Administration | 131,200 |
| Lands and Easements | 159,000 |
| TOTAL FIRST COST | $1,671,300 |
| Federal Share | $1,496,300 |
| Non-Federal Share | $ 175,000 |
| Total Investment | |
| First Cost & Interest During Construction | $1,734,900 |
| **ANNUAL COST** | |
| Interest and Amortization | $136,700 |
| Operation and Maintenance | 2,300 |
| Funding for Periodic Equipment Replacement | 2,100 |
| TOTAL ANNUAL COST | $141,100 |
| Federal Share | $122,400 |
| Non-Federal Share | $18,700 |
| ***PROJECT JUSTIFICATION*** | |
| Annual Benefit | $239,700 |
| Benefit-Cost Ratio | 1.7 to 1.0 |

## COMPARISON OF ALTERNATIVE PLANS

To compare the alternative plans described in the previous section, the performance of each plan was measured in terms of four parameters. These were: 1) the fulfillment of the objectives described in the problem and opportunity statements; 2) economic efficiency; 3) impacts ; and 4) public acceptance. A system of accounts table summarizing this comparison follows this discussion.

### Fulfillment of Problem and Opportunity Objectives

Implementation of any of the three plans would respond to some of the flooding problems on Beaver Brook, but none of the plans would eliminate all flood losses on the Brook. Plan C would provide the most reduction in flood losses by combining the structural measures of Plan A with the automated warning system of Plan B, to provide stage reductions for frequent events and advanced warning to residents in rare events.

None of the alternative plans developed for Beaver Brook would fully capitalize on the opportunity to enhance the environmental qualities of the basin. Although Plan B would entail the least construction and therefore the least disturbance to the environment, Plans A and C would actually do more to preserve the existing environment. Even though these plans would each involve construction changes to the outlet of the Three Mile Swamp, they would also insure the preservation of the wetland through its aquisition. The assured preservation of the wetland compares favorably to Plan B or the without project condition, since neither of these futures would guarantee a similar stability.

### Economic Efficiency

Table 11 below summarizes the economic analysis for each of the alternative plans.

TABLE 11
ECONOMICS OF ALTERNATIVE PLANS

| | First Costs | Annual Costs | Annual Benefits | Net Annual Benefits | Benefit-Cost Ratio |
|---|---|---|---|---|---|
| Plan A | $1,641,000 | $135,800 | $234,200 | $98,400 | 1.7 |
| Plan B | $ 30,300 | $ 5,300 | $ 10,000 | $ 4,700 | 1.9 |
| Plan C | $1,671,300 | $141,100 | $239,700 | $98,600 | 1.7 |

Table 11 illustrates that each of the plans is economically justified, and that Plan C maximizes net economic benefits. Accordingly, Plan C is designated as the NED plan.

Impacts

Since it is generally agreed that the short-term construction impacts of the alternative plans would not be significant, the difference in the plans lies in their long term effects.

Although implementation of Plans A and C would have more adverse environmental impacts than Plan B, both of these plans would also have the favorable effect of preserving the Three Mile Swamp against future development. The adverse effects of these plans are summarized on the following System of Accounts table,and basically would consist of visual impacts in the vicinity of the outlet structure of the Three Mile Swamp. The advantage of Plan C is that it would optimize the beneficial flood control impacts of the alternative plans by combining all project elements, thereby reducing the fear and anxiety associated with a surprise flood as well as reducing actual flood stages.

Public Acceptance

Public opinion surveys conducted among Keene residents during the previous investigation established that, of all the alternative measures available to control flood losses, the preferred mthods were disaster relief assistance and the construction of dams. Among community business leaders and public officials, the preference was more toward smaller scaled measures that would not commit the city to a large capital investment or hinder local economic development.

The city of Keene indorsed the concept of small scale protective measures in May 1980 when it requested the initiation of this Section 205 investigation. In a subsequent meeting with the Keene City Planner in January of 1983, Plan C was indorsed as the preferred alternative as it would provide the most reduction in annual flood losses.

The circulation of this draft report for a 30-day review period during August and September 1983 provided interested persons with an opportunity to comment on the proposed plan. At the time of release, the recommended plan was Plan C, the NED plan. However, at a meeting of the Keene City Council finance committee, convened to formally determine the city's support for the project, the committee endorsed Plan A as the prefered alternative. The members of the City Council felt that the city already adequately informs itself of impending floods and that the automated flood warning system would not provide any additional information of use to the city.

RATIONALE FOR SELECTED PLAN

As a result of the above decision by the city of Keene, Finance Committee, Plan A was carried as the selected plan. Although Plan A is not the NED plan, it only deviates from the NED plan by $200 annually, and is therefore an acceptable alternative to Plan C.

TABLE 12
SUMMARY COMPARISON OF ALTERNATIVE PLANS
BEAVER BROOK, KEENE, N.H.

| | WITHOUT PROJECT | PLAN A | PLAN B | PLAN C |
|---|---|---|---|---|
| **PLAN DESCRIPTION** | | | | |
| 1. Major Features | Most likely future without Federal project | Construction of modified outlet structure at 3-Mile Swamp and channel improvements between Water Street and Malboro Street. | Implementation of automated flood warning plan. | Combination of Plans A and B. |
| 2. Land taking Requirements | | 18 private ownerships<br>2 public ownerships | Public Lands | Same as Plan A |
| **IMPACT ASSESSMENT** | | | | |
| 1. National Economic Development (NED) | | | | |
| a. Project First Cost | | | | |
| Federal | | $1,472,000 | $0 | $1,496,300 |
| Non-Federal | | 169,000 | 30,300 | 175,000 |
| Total | | $1,641,000 | $30,300 | $1,671,300 |
| b. Average Annual Cost | | | | |
| Federal | | $120,300 | $0 | $122,400 |
| Non-Federal | | 15,200 | 5,300 | 18,700 |
| Total | | $135,000 | $5,300 | $141,100 |
| c. Damage Reduction Benefit | | | | |
| Average Annual Flood Damages | $447,000 | $447,000 | $447,000 | $447,000 |
| Annual Residual Damages | | 212,600 | 437,000 | 207,300 |
| Annual Damage Reduction Benefit | | $234,200 | $10,000 | $239,700 |
| d. Net Annual Benefit | | $98,400 | $4,700 | $98,600 |
| e. Benefit Cost Ratio | | 1.7 | 1.9 | 1.7 |
| 2. Environmental Quality (EQ) | | | | |
| a. *Air Quality | No change | Minor temporary increases in dust pollution during construction | No impact | Same as A. |
| b. *Archaeological/ Historical Resources | No change | Removal of dry stone masonry dam at 3-Mile Swamp is not expected to represent a significant loss. Channel improvements not expected to have an impact on significant prehistoric or historic resources. | No impact | Same as A |
| c. *Natural Resources | Preservation of 30-acre 3-Mile swamp uncertain and subject to political decisions regarding land development. | Preservation of 30-acre Three Mile Swamp assured through fee acquisition. | No change from without project | Same as A. |
| | | 1/2 acre of wetland habitat lost due to construction of dike alongside Rte 10 roadway. 1/2 acre of streambed habitat and 2 acres of upland/bank habitat lost. | Negligible change in habitat due to project features. | Same as A. |
| d. *Water Quality | Considered to be Class B waters. No change expected. | Minor temporary adverse impacts during construction. Low flow pilot channel included in downstream channel improvements would maintain water quality during dry seasons. | No significant impacts. Installation of gaging station would cause minor temporary impacts. | Cumulative effects of Plans A and B. |
| 3. Other Social Effects (OSE) | | | | |
| a. *Aesthetic Values | Scenic view of 3-Mile Swamp from N.H. Rte 10 would remain as long as wetland was preserved. Stone wall dam at outlet of swamp aesthetic. Downstream channel varies from grassy-sloped banks to vertical walls. | View of 3-Mile Swamp from N.H. Rte 10 would be disrupted for a distance of about 900 feet upstream of outlet. Roadside face of dike would be grass-covered. New outlet structure would be highly visible from roadway because of clearing operations required downstream. Channel improvements would result in an increase in stone protection along channel banks, but upper banks would be grass-covered. | No change | Same as A. |
| b. *Noise | No change | Temporary noise associated with equipment required for channel improvement and blasting operations at 3-Mile Swamp outlet. Most disturbance to residential property at Gardner Street; expected to be short term only. | No significant noise | Same as A. |
| c. *Displacement of People | None expected | No households relocated. | Same as A. | Same as A |
| d. *Community Cohesion | Floodplain residents tend to live there for economic reasons and for the particular quality of the neighborhood. | Reduces impact of more frequent floods and therefore improves value and stability of neighborhood. | Less impact than Plan A but group efforts to protect property would increase cohesion. | Combined effects of A and B would provide greatest contribution to community cohesion. |
| e. *Life, Health and Safety | Continued flood threat to residents. | Threat reduced during smaller flood events. Rarer floods would continue to pose a threat. | Warning time would reduce threat by allowing residents to leave floodplain and make alternative arrangements. | Combination of reduced flooding and warning time would reduce health risks of frequent events and safety and life-threat in rarer floods. |

| | WITHOUT PROJECT | PLAN A | PLAN B | PLAN C |
|---|---|---|---|---|
| 4. Regional Economic Development (RED) | | | | |
| a. *Tax Revenues and Local Expenditures | Floodplain land assessments are discounted 25%. City expends funds for emergency efforts required during flood fights. | May increase tax revenues by increasing property values. Fewer emergency expenditures would be required as a result of reduced flooding. | Will not alter the tax base. Plan B would still require emergency aid from city. | Greater effect than Plan A. |
| b. *Business and Industrial | Temporary layoffs have occurred due to disruption of business from flooding. Net income of floodplain residents is less due to flood losses occurring to personal property. | Negative impacts of frequent floods on employment and income would be reduced by Plan A. Project implementation would provide short-term construction employment. | Less effect than Plan A, because of fewer flood damage reduction benefits. No short-term construction activity would occur. | Greatest contribution due to combination of Plans A and B. |
| C PLAN EVALUATION | | | | |
| 1. Response to Problems and Opportunities | | | | |
| a. Reduce Flood-Related Impacts | | Reduces impacts of lesser floods, by reducing stages about 2 feet during 10 year flood. No effect on impacts of rarer floods. | No effect on flood stages, but by providing flood warning allows residents to take precautions against possible impacts of floods. | Greatest reduction in flood losses by reducing stages of frequent events and providing warning time for all flood events. |
| b. Enhance Scenic and Environmental Qualities of Beaver Brook Watershed | | Disrupts scenic quality of existing outlet structure at Three-Mile Swamp, but insures preservation of swamp through fee acquisition. | No change | Same as A. |
| 2. Net Impacts (With vs. Without) | | | | |
| a. National Economic | | Net benefits average $98,400 annually. | Net benefits average $4,700 annually. | Net benefits average $98,600 annually. |
| b. Environmental Quality (EQ) | | Assured preservation of 30 acres of wetland habitat. | No change | Assured preservation of 30-acre wetland habitat. |
| c. Other Social Effects (OSE) | | Improvement in health and safety by reducing flood stages. | Improvement in safety by allowing residences to evacuate the floodplain. | Improvement in health and safety by reducing flood stages and allowing residents to evacuate the floodplain. |
| d. Regional Economic | | Net gain during construction. Long term reduction in City revenues expended for flood-emergencies. | Less than Plan A. | Greater positive impact than Plan A. |
| 3. Response to Evaluation Criteria | | | | |
| a. Completeness | | Complete | Completeness requires discontinuation of warning by city. | Same as Plan B. |
| b. Effectiveness | | Partially effective in addressing problems and opportunities. | Less effective than Plan A. | More effective than Plan A. |
| c. Efficiency | | Efficient | Efficient | Efficient |
| d. Acceptability | | Most Acceptable | Least Acceptable | Acceptable |
| e. Flood Plain Regulations (EO11988 and EO11990) | | Construction in waterway most efficient method of reducing flood losses | No construction in waterway | Same as Plan A. |
| 4. Ranking of Plan Contributions | | | | |
| a. NED Objective | | 2 | 3 | 1 |
| b. EQ Account | | 1 | 3 | 2 |
| c. OSE Account | | 2 | 3 | 1 |
| d. RED Account | | 1 | 3 | 2 |
| D IMPLEMENTATION RESPONSIBILITY | | | | |
| 1. Plan Cost | | | | |
| a. Federal | | $1,472,000 | $0 | $1,496,300 |
| b. Non-Federal | | 169,000 | 30,300 | 175,000 |
| c. Total | | $1,641,000 | $30,300 | $1,671,300 |
| 2. Annual Cost | | | | |
| a. Federal | | $120,500 | $0 | $122,400 |
| b. Non-Federal | | 13,300 | $3,300 | 18,700 |
| c. Total | | $133,800 | $3,300 | $141,100 |

## THE SELECTED PLAN

### PLAN DESCRIPTION

The selected plan, previously described as Plan A, consists of structural modifications to the outlet of the Three Mile Swamp, and widening the Beaver Brook channel in the reach between Water Street and Marlboro Street. Design details of the plan are located on Plates 4 through 10. A proposed sequence for construction of the new outlet structure has also been prepared and is presented on Plate 13. The modification of the Three Mile Swamp would improve the swamp's ability to attenuate flood flows by increasing the amount of temporary storage occurring in the swamp during flood periods. The downstream channel improvements would increase the channel capacity and reduce overbank flooding during smaller flood events. Detailed information concerning the design and materials of the recommended plan is presented in the geotechnical report contained in the supporting documentation, and in the discussion of alternative plans, presented earlier.

### PROJECT COST

Detailed information concerning the costs of the three project elements is presented in Table 13. In total, the plan would have a first cost of $1,641,000, and annual costs of $135,800.

TABLE 13
ESTIMATE OF FIRST COSTS AND ANNUAL CHARGES
RECOMMENDED PLAN

FIRST COSTS

1) Three Mile Swamp Outlet Structure

| Item | Quantity | Unit | Unit Price | Cost |
|---|---|---|---|---|
| Site Preparation | 1 | JOB | L.S. | $ 4,000 |
| General Excavation | 16,800 | CY | 5.00 | 84,000 |
| Rock Excavation | 2,000 | CY | 20.00 | 40,000 |
| Stone Protection | 4,200 | CY | 30.00 | 126,000 |
| Dumped Gravel Fill | 2,600 | CY | 7.00 | 18,200 |
| Compacted Gravel Fill | 3,200 | CY | 8.00 | 25,600 |
| Compacted Impervious Fill | 7,500 | CY | 6.00 | 45,000 |
| Compacted Random Fill | 3,000 | CY | 4.00 | 12,000 |
| Gravel Bedding | 1,900 | CY | 8.00 | 15,200 |
| Seeded Topsoil | 5,000 | SY | 3.00 | 15,000 |
| Concrete | 2,500 | CY | 175.00 | 437,500 |
| 48" Reinf. Conc. Pipe | 150 | LF | 85.00 | 12,750 |
| Diversion of Water | 1 | JOB | L.S. | 10,400 |
| | | Subtotal - Outlet Structure | | $845,650 |

2) Channel Improvements

| Item | Quantity | Unit | Unit Price | Cost |
|---|---|---|---|---|
| Site Preparation | 1 | JOB | L.S. | $ 1,000 |
| Earth Excavation | 10,500 | CY | $ 5.00 | 52,500 |
| Stone Protection | 3,400 | CY | 30.00 | 102,000 |
| Compacted Random Fill | 700 | CY | 4.00 | 2,800 |
| Gravel Bedding | 2,100 | CY | 8.00 | 16,800 |
| Seeded Topsoil | 1,500 | SY | 3.00 | 4,500 |
| Relocation of Utilities | 1 | JOB | L.S. | 10,000 |
| | | Subtotal - Channel Improvements | | $189,600 |

| | |
|---|---|
| PROJECT SUB-TOTAL | $1,035,250 |
| Contingencies | 186,350 |
| CONSTRUCTION COST | $1,221,600 |
| Engineering & Design | 132,000 |
| Supervision & Administration | 128,400 |
| Lands & Easements | 159,000 |
| TOTAL PROJECT COST | $1,641,000 |
| Federal Share | $1,472,000 * |
| Non-Federal Share | 169,000 |

Investment Cost
First Cost & Interest During Construction $1,704,300

*Does not include preauthorization costs of $210,000

ANNUAL COSTS

| | |
|---|---|
| Interest and Amortization | $134,300 |
| Operation and Maintenance | 1,500 |
| TOTAL ANNUAL COST | $135,800 |
| Federal Share | $120,500 |
| Non-Federal Share | 15,300 |

PROJECT JUSTIFICATION

| | |
|---|---|
| Annual Benefit | $234,200 |
| Benefit-Cost Ratio | 1.7 to 1.0 |

PROJECT OPERATION

Following construction and implementation of the proposed project, the City of Keene would be responsible for the operation and maintenance of the project features. The project features are designed to operate automatically with no action required of the local sponsor. The outlet structure at Three Mile Swamp is a self-regulating spillway with no gateworks that require operation during flood periods. One exception to the absence of an operation requirement is the dike adjacent to Route 10, which provides two feet of freeboard against the stage of the Standard Project Flood. At the location where the dike alignment intersects Route 10, the surface elevation of the roadway is 2 feet lower than the top of the dike, representing an opening in the freeboard range. If freeboard protection was ever required at this location, the City of Keene would have to sandbag Route 10 to maintain control of flood flows.

Maintenance costs for the project are estimated to total $1,200 annually, including annual dredging of silts from the channel invert, and periodic repairs to the Three Mile Swamp outlet structure.

PROJECT ACCOMPLISHMENTS

Implementation of the proposed project would result in stage reductions of 2 to 2.5 feet during the 10-year flood with lesser stage reductions during larger flood events. The proposed project would reduce annual flood losses from $447,100 to $218,500, providing an annual flood damage reduction benefit of $228,600. Affluence benefits accruing to flood prone property in the future would bring total project benefits to $234,200 annually.

PROJECT EFFECTS

In addition to reducing flood damages in the Beaver Brook flood plain, the proposed project would ensure the preservation of the Three Mile Swamp through the acquisition of project lands. Minor negative effects of the project would include the loss of one acre of wooded habitat downstream of the existing Three Mile Swamp dam, and the obstruction of the view of the swamp from the Route 10 roadway for a

distance of about 900 feet upstream of the outlet. Access to the swamp for canoeists and anglers would not be disrupted by the project.

## ECONOMIC EVALUATION

The proposed plan of improvements for the Beaver Brook watershed would have a benefit to cost ratio of 1.7 to 1.0, with an estimated annual benefit of $234,200. Annual costs of $135,800 have been determined by amortizing the first project costs over a 100-year project life at an interest rate of 7-7/8 percent and adding in operation and maintenance costs. Operation and maintenance costs are estimated to total $1,200 annually.

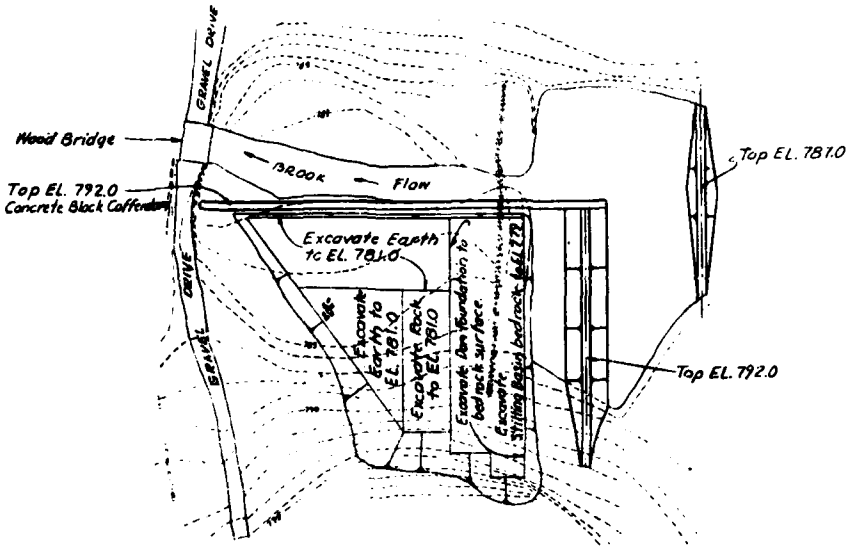
## COST ALLOCATION

The sole purpose of the proposed project is flood damage reduction and all costs have been allocated as such. Under the traditional cost-sharing requirements for Section 205 local protection projects, the local sponsor of the project must provide lands, easements, rights-of-way and utility relocations required for the project and assume responsibility for operation and maintenance of the project after it is constructed. This division of cost responsibilities is established by Section 3 of the 1936 Flood Control Act, as amended. Table 14 below presents a division of project costs between the Federal and non-Federal sponsor, based on traditional cost-sharing policies. Future changes in cost-sharing-policies are likely however, and a higher level of participation than specified below may ultimately be requested of the city of Keene.

TABLE 14
TRADITIONAL COST SHARING FOR SELECTED PLAN
($1000)

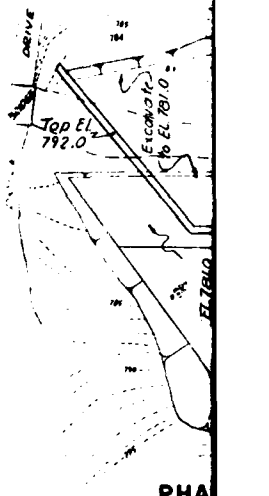
| | Total Project Costs | Percent of Total |
|---|---|---|
| Federal | $1,472 | 90 |
| Non-Federal | $ 169 | 10 |
| Total | $1,641 | 100 |

CORPS OF ENGINEERS




## PHASE I PLAN

SCALE 1" = 40'

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## PHASE I

1. Construct Upstream Wildlife Impoundment Dam across the brook with top EL. 787.0
2. Construct temporary cofferdam to EL 792.0
3. Remove existing dam down to EL. 783.0
4. Excavate earth and bedrock inside cofferdam.
5. Remove cofferdam
6. Divert brook to left side

PHASE

1 Construct coffer

2. Excavate earth a cofferdam.

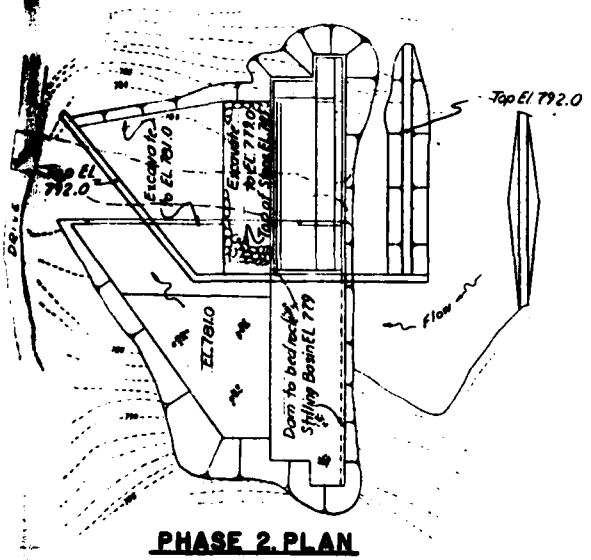
3 Construct concr basin inside cof

4 Place stone prot cofferdam.

5. Place rock slope

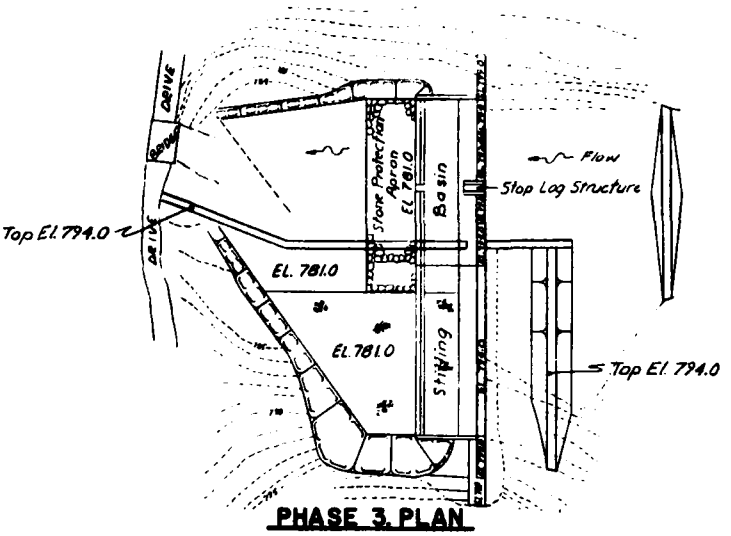
6. Remove coffer

1




**PHASE 2. PLAN**

SCALE 1" = 40'




**PHASE 3. PLAN**

SCALE 1" = 40'

## PHASE 2.

1. Construct cofferdam to EL. 792.0
2. Excavate earth and rock inside the cofferdam.
3. Construct concrete dam and stilling basin inside cofferdam.
4. Place stone protection apron inside cofferdam.
5. Place rock slope protection
6. Remove cofferdam.

## PHASE 3.

1. Construct cofferdam to El. 794.0 and divert flow thru stoplog structure
2. Complete construction of concrete dam and stilling basin.
3. Place rock slope protection
4. Remove cofferdam
5. Complete discharge channel and rock slope protection to wooden bridge.
6. Remove upstream cofferdam.

GRAPHIC SCALE

1" = 40' 40' 0 40' 80'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEAVER BROOK

# FLOOD DAMAGE REDUCTION

KEENE, NEW HAMPSHIRE

DIVERSION OF WATER

PLATE

2

## PLAN IMPLEMENTATION

Following the review and approval of this document by the Chief of Engineers and the allocation of funds, plans and specifications for the project features will be prepared. During the preparation of plans and specifications the City of Keene and/or the State of New Hampshire would be required to sign a formal document reaffirming their support for the project and their intent to fulfill the items of local cooperation. Following the receipt of these formal assurances and project funding, the Corps would invite bids for the award of a contract for construction of the project.

It is anticipated that the preparation of plans and specifications could be completed by the fall of 1984 and contingent upon the availability of funding and receipt of local assurances, construction could begin the next season.

## SUMMARY OF PUBLIC INVOLVEMENT

Public involvement in the planning process was initiated during the previous investigation when a committee of local citizens was formed and Keene city residents and community business leaders were interviewed to determine their perception of the flooding problem in Keene. The results of these surveys, which are summarized in the Public Involvement appendix, indicated that Keene city residents generally felt that disaster relief assistance was the prefered method of flood damage reduction but that dams were also a preferred solution. On the other hand, local officials and business leaders tended to favor smaller-scaled individual efforts to combat flooding and they were very supportive of the flood insurance program.

At the conclusion of the congressionally authorized study of non-structural solutions to the flood problem, the city of Keene endorsed further study of small scale structural measures by requesting initiation of this Section 205 investigation. A copy of this letter is included in the Public Involvement appendix.

Review of the proposed plans of improvement by the U.S. Fish & Wildlife Service resulted in a Final Coordination Letter dated May 18, 1983, endorsing the nonstructural alternative. This letter is also presented in the Public Involvement appendix. No comments were received from the State Department of Resources and Economic Development concerning the archaeological reconnaissance report for the proposed project.

In August 1983 a 30-day review period was initiated to seek public comments on the Draft Detailed Project Report and Environmental Assessement. Comments received in response to this review, together with letters addressing these comments are displayed in the Public Involvement Appendix. As a result of this review, the State of New Hampshire declared its intent to support the project in a letter dated 6 September 1983. The city of Keene discussed the project at a meeting of the City Council Finance Committee on 10 November 1983, at which time it endorsed Plan A as the preferred plan. The full City Council adopted the report of the Finance Committee on 19 January 1984, and forwarded a notice of the city's intent to support the proposed project in a letter dated 27 January 1984. Both letters of intent are displayed in the Public Involvement Appendix. A Water Quality Certificate for the proposed work was issued by the State of New Hampshire in a letter dated 20 October 1983.

## RECOMMENDATIONS

I recommend that the flood damage reduction measures described as the Selected Plan in this report be authorized for construction as a Federal project, with such modifications as the Chief of Engineers may deem advisable. Total project first costs amount to $1,641,000, of which the Federal first cost totals $1,472,000. Non-Federal first costs are estimated to total $169,000.

The non-Federal sponsor of this project would be the State of New Hampshire which would be responsible for the following items of local cooperation.

1. The State agrees that, if the Government shall commence implementation of the Beaver Brook Flood Damage Reduction Project in Keene, New Hampshire substantially in accordance with the approval of the Chief of Engineers under Section 205 of the 1948 Flood Control Act, as ammended, the State shall in consideration of the Government commencing such project, fulfill the requirements of non-Federal cooperation, to wit:

a. Provide all lands, easements, rights-of-way, utility relocations and alterations necessary for project implementation. Real estate costs are currently estimated to be $159,000. Utility relocations are currently estimated at $10,000.

b. Hold and save the United States free from damages due to the construction, operation, and maintenance of the project except where such damages are due to the fault of the United States or its contractors.

c. Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army. This subparagraph shall be construed to apply to all aspects of the project including lands acquired within the flood plain which must be maintained in a manner that prevents future encroachment which might interfere with proper flood plain management and the functioning of the project for flood control. Annual operation and maintenance costs are currently estimated at $1,500.

d. Assume full responsibility for all project costs in excess of the Federal statutory limitation of $4,000,000 which includes costs of all investigations, planning, engineering, supervision, inspection, and administration involved in development and project implementation. Total Government participation including investigations and planning costs is estimated to equal $1,682,000. All costs shall be computed on the basis of actual costs at the completion of the project and not on the basis of estimates contained in this report.

e. Comply with the requirements of non-Federal cooperation specified in Sections 210 and 305 of Public Law 91-646 approved 2 January 1971 entitled the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970".

f. Comply with Section 601 Title VI of the Civil Rights Act of 1964 (Public Law 88-352) to the end that no person shall be excluded from participation in, denied the benefits of or subjected to discrimination in connection with the project on the grounds of race, creed, or national origin.

g. Twice yearly inform residents and property owners within the Beaver Brook floodplain of the limitations of the flood control improvements and alert them to the continued threat of major flooding along the Brook.

I recommend that funding in the amount of $160,000 be provided to prepare plans and specifications for the following:

a) the construction of a new outlet structure at Three Mile Swamp; and

b) the construction of channel improvements in the reach between Water Street and Marlboro Street.

An additional $212,000 in funds would be required in FY84 to initiate construction and implementation of the proposed project, with a balance of $1,100,000 required in FY85 to complete project construction.

DATE 14 Feb '84

CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer

FINDING OF NO SIGNIFICANT IMPACT

The Environmental Assessment for this project is attached and describes the proposed action, need for the project, alternatives to the project, affected environment and environmental consequences.

Implementation of the proposed project will not require a significant commitment of physical, natural or human resources. Coordination among all parties during the planning process has resulted in the recommended proposal. The impacts have been outlined in the assessment and are summarized below.

The increased noise and dust caused by earth moving activities at Three Mile Swamp and the reach of Beaver Brook in downtown Keene, New Hampshire would temporarily degrade fish and wildlife habitat during the construction period. Dewatering of the pond/wetland and streambed habitats at Three Mile Swamp would occur only during the construction period and, together with other appropriate measures, would control siltation into the downstream aquatic habitat. The pond level would be restored to its original elevation after construction ceases. The permanent removal of the small acreages of wetland, upland and riparian habitats represents a small percentage of like available habitats in other nearby areas of the basin. The increased storage in the pond/wetland at Three Mile Swamp during flood events that would be utilized by the new concrete dam would not have an adverse impact on the adjacent upland vegetation. Loss of the scenic vista of the Three Mile Swamp would not be significant because other equally aesthetially pleasing views occur areas upstream of the project area. No impacts to the historical/archaelogical resources are anticipated. Adverse impacts to socioeconomic resources would include increased noise and dust level due to construction activities in and around the work areas. These would be short term and of little consequence to nearby residences. The beneficial long term effect would be the protection of local homes and businesses from minor flood events.

There does not appear to be any remaining major environmental problem, conflict or disagreement in implementing the proposed work. I have determined that implementation of the proposed action will not have a significant impact on the human environment and, therefore, will not require an Environmental Impact Statement.

14 Feb '84
DATE

CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer

## Summary

Structural flood control measures are proposed for Keene, New Hampshire along Beaver Brook. An existing breached stone dam at an upstream wetland would be replaced by an ungated concrete outlet structure having a stepped spillway which is designed to maintain the existing pool during non-flood periods and utilize additional surcharge storage during a flood event. Associated with the new dam would be a concrete stilling basin and earthen dike on the west bank to protect the adjacent Route 10. A 1750 ft. reach of Beaver Brook in the downtown Keene is proposed for channelization. The proposed improvements involve widening the channel and banks to obtain an even slope and width throughout the reach. The channel bottom would be graded to create deeper channel center for maintenance of water quality and fish passage during summer low flows. The proposed measures would provide protection by reducing the flood stages of less than 20-year events. Also, proposed and evaluated are a nonstructural alternative (flood forcast and warning system) a combination structural and nonstructural alternative and a "no action" alternative.

The proposed project would have impacts to the natural and socioeconomic resources in the project area. No impacts to significant historical/archaeological resources in the area are anticipated.

Impacts to the natural environment consist of short-term construction related and long term effects. Construction impacts would involve temporary dewatering excavation and fill activities in the wetland and stream bed area. These activities would cause increased noise and dust in the work area and siltation in the downstream reaches and would temporarily degrade fish and wildlife habitat in the project area. Dewatering of the work area and use of the silt control measures would mimimize the siltation and impacts to the downstream aquatic habitats. The major long term impacts involve the permanent removal of 0.5 acres of streambed, 0.5 acres of wetland and 2.0 acres of upland/streambank habitats. The loss of the natural streambed habitat would be partially offset by the creation of a limited number of new microhabitats made available by the stone lining in the channel. The habitats represent a small percentage of available like habitat in other nearby areas of the basin. The wetland and upland habitats would be subjected to inundation during flood events. However, storage would not occur for longer than a 48 hr. period and should not have adverse impacts to the vegetation in these areas. The area does provide a scenic vista which would be obstructed due to the placement of the new outlet structure and dike.

The proposed work would not impact significant historical/archaeological resources in the project area.

The impacts to socioeconomic resources would also be short and long term in nature. Site specific construction related effects would be felt in two particular areas; Three Mile Swamp and the channel between

Marlborough and Water Streets. These would include increased truck travel, noise and dust pollution. Post-construction impacts would be felt most directly by homes and businesses in the immediate area of the brook which would receive protection from "nuisance" flood events. Significant alteration of the scenic quality of the Three Mile Swamp area would occur with construction of a new outlet structure.

## I. Project Description

Structural flood control measures are proposed for Keene, New Hampshire along Beaver Brook. A new floodwater retarding structure would replace an existing stone dam at the outlet of an upstream wetland called Three Mile Swamp. Also, channel improvements are proposed in the downtown Keene area for Beaver Brook between Marlboro and Water Streets.

The new floodwater retarding structure at Three Mile Swamp would have an ungated stepped concrete spillway with a non-overflow section constructed to elevation 799 ft. National Geodetic Vertical Datum (NGVD). The stepped spillway is designed to maintain the existing pool elevation during non-flood periods and utilize additional surcharge storage during a flood. During the Standard Project Flood, the pool behind the dam would rise to elevation 797 ft. NGVD for a duration of less than 48 hours. In order to maintain control of the floodwaters at the outlet, a 12 ft. high earthen dike would be constructed along the west bank of the wetland to prevent overflows on Route 10, which parallels the bank. Placement of the modified outlet structure would also involve the construction of a stilling basin downstream of the concrete spillway and tapering of the channel width from the 200 ft. spillway width to the existing channel width downstream. The proposed channel improvements for Beaver Brook in downtown Keene involve widening the channel and banks to obtain an even slope and width of the brook throughout its reach. The channel width would be increased to 17 ft. with sides sloped to 1 vertical on 2 horizontal and lined with riprap to a vertical height of 4 ft. above the invert. Grasses would be planted on the upper bank for stabilization. The channel bottom would be graded to create a deeper channel center for maintenance of water quality and fish passage during summer low-flows.

A more detailed project description may be found in the Description of Alternative Plans Section of the Detailed Project Report.

## II. Need for the Proposed Project

Without the proposed flood control improvements along Beaver Brook, residents of the flood plain can expect to continue experiencing nuisance flooding on an annual basis with wet basements and utility disturbances a common occurrence. Major floods, more dangerous in their threat to human health and safety, and more damaging in their destruction of property, will also continue unchecked. In total, there are approximately 384 residential, 45 commercial and 13 industrial units, that would be effected during a Standard Project Flood on Beaver Brook. In February 1983 dollars, flood losses to these properties are estimated to average $447,000 annually. If a flood having a frequency of occurrence of once in 100 years were to occur today, it would result in approximately $4.4 million in losses.

## III. Alternatives

Three alternative flood control plans have been formulated for local protection of the Keene area: Plan A, the proposed structural alternative; Plan B, the non-structural alternative; Plan C, the combined structural and non-structural alternative; a "no action" alternative has also been included.

Plan A includes the new concrete outlet, stilling basin and earthen dike at Three Mile Swamp and the channel improvements to Beaver Brook in the downtown Keene area between Marlboro and Water Streets. This has been described as the proposed project in Section 1 of this Environmental Assessment and in more detail in the Description of Alternative Plans of the Detailed Project Report. This plan would provide protection by reducing the flood stages of less than 20-year events but would have impacts to the natural and socioeconomic resources in the project area.

Plan B involves an automated flood forcasting and warning system which would involve the installation and programming of equipment necessary to provide a warning capability to the city, including predictions of peak flood stage. The equipment includes rain, temperature and stream gages in the upper watershed which would be connected with a microcomputer located at the city's forcasting center in Keene. In addition to its receiving function, the computer would also be capable of transmitting information to the National Weather Service's central computer in Bloomfield, Connecticut. This alternative provides a minimal amount of protection to flood prone residents with no impact to the natural or socioeconomic resources in the watershed. A more detailed description may also be found in the Description of Alternative Plans section of the Detailed Project Report.

Plan C is a combination alternative which would incorporate the structural measures described in Plan A and the non-structural measures of Plan B. This plan would maximize the potential flood protection benefits by adding the warning capability of Plan B for rare, more damaging flood events to the flood protection provided for the lesser, more frequent events by Plan A. The impacts to the existing resources would be essentially the same as Plan A.

The "no action" alternative means that flood control measures would not be implemented for the Keene area. This implies that no impacts would occur to the project area resources and flooding would continue as it has in the past with little or no warning to the area residents.

## IV. Environmental Setting

The existing environment in the Keene area consists of natural, historical, archeological and socioeconomic resources.

AD-A143 376 BEAVER BROOK KEENE NEW HAMPSHIRE FLOOD DAMAGE REDUCTION PROJECT DETAILED..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV FEB 84 2/2

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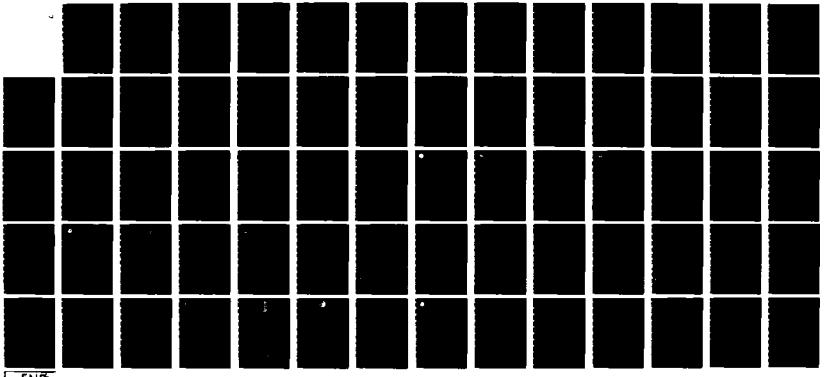

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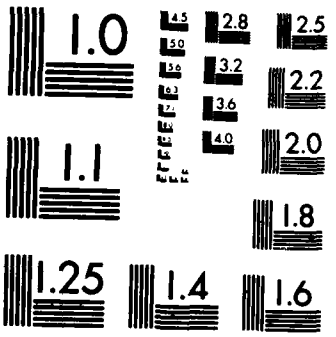

A. Natural Resources

1. General: Beaver Brook is a tributary of the Ashuelot River in the Connecticut River Basin and is located in the uplands of southeastern New Hampshire. Its headwaters begin at Bingham Hill State Forest in the town of Gilsum from which it flows in a general southerly direction to its confluence with the Ashuelot River about one mile south of the central business district in the city of Keene. It generally runs adjacent to New Hampshire Route 10. The watershed is generally rectangular in shape with a length of about seven miles, an average width of one and a half miles and a total drainage area of about 10 square miles. The upper basin is primarily forested and underdeveloped except for scattered residences whereas the lower basin flows through the urban setting in Keene.

The New Hampshire Water Supply and Pollution Control Commission indicated that Beaver Brook is classified as a class "B" stream. This indicates that the water has a high aesthetic value and would be acceptable for swimming and other recreation, fish habitat, and after treatment, for use as water supply.

2. Natural Environment of the Project Areas. Two specific areas of the basin have been proposed for structural flood control measures; Three Mile Swamp and the Beaver Brook channel between Water and Marlboro Streets in downtown Keene.

a. Three Mile Swamp.

Three Mile Swamp is located about 3.5 miles upstream of the Beaver Brook confluence with the Ashuelot River (see Plate 2 of the Detailed Project Report) and contains aquatic, wetland and terrestrial habitats.

The aquatic and wetland habitats include an impoundment along Beaver Brook created by a breached stone dam and the downstream reach of the brook below the dam. The impoundment is a 25-acre 6-foot deep pond that is limited by the topography of the Beaver Brook floodplain. Several wetland types occur in the area ranging from emergent wetland to scrub-shrub swamp with small patches of aquatic bed and forested wetlands. The shoreline areas support such wetland vegetation as steeplebush, meadowsweet, speckled alder, sweet gale, leatherleaf, dogwoods, cattail, pond lilies and an assortment of pond weeds (Potomogeton spp.), sedges (Carix spp.) and grasses (Graminacae). The riverine habitat downstream of the dam is about 20 feet wide, 1-2 feet deep and contains numerous boulders and cobbles. Streamside vegetation is thick consisting of an assortment of trees, shrubs and understory which are contiguous with the adjacent forested area described below. The stream gradient is relatively flat but increases downstream for a distance of 2 miles. The outflow of the dam and the stoney nature of the streambed create a moderately developed riffle habitat downstream of the dam.

The east side of the swamp is bordered by an upland second growth forest. Eastern hemlock is the dominant species near the dam whereas white pine is more common on the hill overlooking the bank. A selective cutting in 1979 has removed all the merchantable white pine on the hill. The trees were estimated to be about 75 years old from the annual rings on the stumps. Common hardwoods include red and sugar maple, red and white oak, paper birch and American elm. Common understory species include American yew, club moss, arrowwood, wintergreen and a variety of ferns.

The swamp supports moderate quality fish and wildlife resources of local significance. Aquatic animal life in the area includes a variety of insects, amphibians and fish. Chain pickerel, brown bullhead, yellow perch and various forage species such as minnows and darters comprise the most important fish species. The New Hampshire Fish and Game Department (NHFG) annually stocks about 500 legal length (7-9 inches) brook trout upstream of the swamp. The river and impoundment areas do provide habitat for this species until the water warms to about $70^{o}$. Warming occurs during the summer because the river upstream of the dam and the impoundment are shallow and well exposed. However, most trout are harvested or pass downstream to the Ashuelot River by the time the water temperature becomes too warm. Current utilization of this fishery is low.

The NHFG has indicated that the area also provides excellent habitat for waterfowl. Black and wood ducks both have nested in the area. The eggs are usually laid around the beginning of May and hatch about one month later. Other gamebirds such as ruffed grouse and woodcock occur and are hunted in the area. Song birds associated with the wetland include red-winged blackbird, tree swallow, kingbird, crow and a variety of warblers. Raptors such as hawks and owls occasionally use the swamp. Mammalian wildlife such as beaver, muskrat, mink, otter and hare are occasionally trapped in the area. The NHFG has indicated that the edge habitat created by the power line crossing on either side of Route 10 provides wintering habitat for white-tailed deer.

The swamp has a pleasing scenic vista and often becomes the focal point for passing motorists along Route 10. Bird watching, identifying wildflowers and walking around the swamp's perimeter are popular recreational opportunities in the area.

b. Beaver Brook in downtown Keene.

The second project area is the 1750 ft. reach of Beaver Brook between Marlboro and Water Streets in the downtown Keene area (see Plate 2 of Detailed Project Report). The reach is basically in an urban setting with commercial and industrial buildings and parking lots adjacent to the bank area. The bank habitat is generally disturbed vegetation consisting mainly of grasses and other herbaceous vegetation with occassional shrubs and trees (usually maple, oak or ash). The brook is generally well exposed to the "elements" with widths ranging from 8 to 15 ft. and depths of 1-2 feet. The stream bottom is generally hard consisting of cobbles,

sand, gravel and some boulders. Little to no aquatic vegetation or fish cover exists along the reach. The brook does provide marginal habitat for aquatic insects and frogs and provides passage for upstream fish to the Ashuelot River. Some fishing by young anglers occurs in the area. Sections of the reach are used by a variety of urban and stream associated wildlife such as chickadee, crow, sparrows, cardinal, robin, grackle, pigeon, catbird, mourning dove, squirrel, moles, rabbit, skunk, mice and other rodents.

c. Threatened or Endangered Species

The U.S. Fish and Wildlife Service has indicated that the project area does not contain critical habitat for any Federally listed threatened or endangered species.

B. Historical/Archeological Resources

Prehistoric archaeological sites in the Ashuelot Valley date from the Paleo-Indian period (ca. 9000 BC) to the mid 18th century, and generally represent short-term occupations probably related to a primarily riverine resource base. The valley also appears to have been a travel route during this period. Upland areas such as Three Mile Swamp are less likely to have been habitation areas, but would have been part of the hunting territory for valley-based groups and could contain very small camp locations. An archaeological reconnaissance of the Three Mile Swamp area (see supporting documentation) revealed possible evidence of some prehistoric activity in the area, but the material found is more likely of natural origin.

Historic occupation in the area began in the 18th century, at which time Keene was primarily centered around the timber industry. Most of Keene's present character developed during the 19th century, when industrial and commercial activity began to dominate the local economy. Keene's position as county seat and the development of railroad links furthered these trends and population density increased dramatically.

The downstream portion of the project area was fairly undeveloped in the 19th century, as Beaver Brook flowed behind residences and industries and had limited waterpower potential within this reach. The only historic period features within the project area consist of retaining walls and bridge abutments of little historic interest.

The only historic period feature within the Three Mile Swamp portion of the project area is a breached fieldstone and earth dam with remains of a concrete sluice. This structure appears to be of late 19th century date, and did not include any adjacent industrial buildings. It was probably built for storage to supply downtown mills with adequate waterpower during dry seasons. Such dams were commonly built in the late 19th century, and this example has little historic or engineering interest.

## C. The Study Area - Socioeconomic Resources

### a. Population

The city's population growth has been moderate and steady since the turn of the century. Keene's greatest period of growth was between 1920 and 1930, when many of the industrial and commercial firms now located in the city were founded. The period between 1970 and 1980 saw growth of 4.8 percent, a rate much reduced from the previous three decades. Keene's 1980 population stood at 21,449, making up about 35 percent of Cheshire County's population. However, between 1970 and 1980 the county had a population increase of 18.6 percent from 52,364 to 62,116. Population figures for Keene are shown in Table 1.

Table 1
Population Growth in Keene
1900-1980

| | Population | Absolute Change | Percent Change Over Previous Decade |
|---|---|---|---|
| 1980 | 21,449 | 982 | 4.8 |
| 1970 | 20,467 | 2,905 | 16.5 |
| 1960 | 17,562 | 1,924 | 12.3 |
| 1950 | 15,638 | 1,806 | 13.1 |
| 1940 | 13,832 | 38 | 0.3 |
| 1930 | 13,794 | 2,584 | 23.1 |
| 1920 | 11,201 | 1,142 | 11.3 |
| 1910 | 10,068 | 903 | 9.9 |
| 1900 | 9,165 | - | - |

Keene's growth has not been as rapid as growth across the State of New Hampshire. Between 1970 and 1980 the State's population grew 24.8 percent. Keene has not been subjected to the intense growth pressure found in the southeastern New Hampshire areas, which have been the greatest contributors to the State's growth. Migration to Keene has been more a result of spinoff development from Brattleboro and other Connecticut River communities than from the Boston metropolitan area.

Using 1980 Census Block figures, the population in the Beaver Brook flood plain approximates 1,590 persons. A survey done citywide including both non-flood plain and flood plain respondents reveals a profile of flood plain residents.

It was found that flood plain residents are more likely than non-flood plain residents to rent their homes (a higher proportion of non-flood plain residents have low or moderate incomes, and a higher proportion are handicapped or elderly). Flood plain neighborhoods tended to include higher shares of the city's sub-standard housing. At the same time, residents of flood plain neighborhoods tended to live in these areas for a longer period of time.

Population projections provided by the city of Keene are shown below.

| | |
|---|---|
| 1990 | 23,500 |
| 2000 | 25,600 |
| 2010 | - |
| 2020 | 29,900 |

These projections indicate modest growth of about 10 percent over the 40 year period from 1980 to 2020. Growth in Keene is projected far below growth in Cheshire County and the State. The county population is projected to increase about 60 percent between 1980 and 2030 and the State's 64 percent.

b. Economy

The Ashuelot River and its tributaries, including Beaver Brook, provided sufficient power to attract many mills to Keene by the early 19th century. These mills engaged in a wide variety of activities ranging from finishing and weaving cloth to forges, iron foundries and woodworking mills.

Eventually, the industrial activities that came to dominate Keene relied on other locally available resources besides river power. The manufacture of chairs and other wood products took advantage of the area's timber resources. By the late 1880's, bricks made in Keene were used in construction throughout New England.

By the turn of the century, industrial activities in Keene were still growing, with an increased emphasis on the production of intermediate goods, such as machinery used in other industrial processes.

Employment in the Keene Labor Market Area* (LMA) is concentrated in manufacturing. In 1981, employment in manufacturing was 40.4 percent of the area's total employment. The manufacturing sector was followed by the services sector, accounting for 23.6 percent of the area's employment opportunities, and the wholesale and retail trade sector, accounting for 21.4 percent. Table 2 shows the average annual employment in each sector for 1981 and total wages and average weekly wages. Unemployment in the LMA averaged 3.6 percent.

* Communities in the Keene LMA include all the communities in Cheshire County plus Greenfield, Hancock, Peterborough, and Sharon in Hillsborough County.

Table 2
Employment by Industry
Keene LMA, 1981

| Industry | Annual Avg. Employment | % of Total | Total Wages | Avg. Weekly Wages |
|---|---|---|---|---|
| Manufacturing | 9,920 | 40.4 | $158,092,460 | $306.48 |
| Construction | 1,322 | 5.4 | 18,543,483 | 269.75 |
| Trans., Comm.,Util. | 403 | 1.6 | 5,369,287 | 256.22 |
| Wholesale & Retail Trade | 5,262 | 21.4 | 49,569,677 | 181.16 |
| Fin., Ins., & Real Estate | 1,869 | 7.6 | 25,612,515 | 263.54 |
| Services | 5,785 | 23.6 | 57,658,950 | 191.67 |
| Total | 24,561 | 100.0 | 314,846,372 | 246.52 |

The unemployment rate for Keene as of December 1, 1982 was 6.1 percent while the State's average was 7.1 percent.

Numerous manufacturing and industrial firms are located in the Beaver Brook flood plain, with the heaviest concentration between Railroad Street and Marlboro Street. Approximately 1,000 persons are employed in industries close to Beaver Brook.

c. Land Uses

Keene's topography has strongly influenced land use development in the city. The valleys of the Ashuelot River and Beaver Brook have provided flat, easily developable areas. The steep slopes and fragile soils of hillsides bounding the valleys have led to the concentration of development in the valleys.

The central business district (CBD) in Keene is located around Main Street between Marlboro Street and Central Square and makes up about 15 percent of the commercially developed land in the city. Main Street and the adjacent side streets are lined with a mix of older multi-story commercial blocks and modern retail and professional buildings. Parking for the CBD is provided along Main Street and a number of small public lots on side streets.

Redevelopment occurring in the CBD is expected to continue. Several buildings off Main Street have been demolished, and parking lots have been created in their places. Most of this redevelopment is outside of floodprone areas with the exception of the Princess Shoe Building. Upon completion of its renovation this old warehouse would increase its usable space from 60,000 square feet to 90,000 square feet. Other major redevelopment within the CBD would be related to renovation of older buildings and new construction on the former railroad land.

The majority of Keene's remaining commercial development lies outside the CBD in shopping malls, including the CBS Plaza, Mart Plaza, and the

Riverside Shopping Plaza, located off Winchester Street north of the bypass. The Keene Shopping Plaza, at the intersection of West Street and Route 12, and commercial development along West Street connect the West Street shopping area to Keene's downtown.

Future commercial development outside of the CBD is likely to occur near the malls off Winchester Street in the form of additions to existing shopping plazas. Several car dealerships are expected to locate along the east side of Winchester Street south of the bypass. These lots are located in the 100-year flood plain.

Keene's industrial development is concentrated in four locations. A number of small factories east and west of the CBD along the Boston and Maine Railroad tracks were among the original industrial sites in Keene. Larger industries are located in the industrial park bounded by Optical Avenue and Route 101. The other two industrial sites are located to the east and west of Winchester Street, south of the Keene bypass.

It is in these areas that future industrial development is anticipated over the next 20 years, including the remaining sites in the KIDPA Industrial Park, the land north of KIDPA Park, and property west of Winchester Street south of the bypass. Industrial development is also expected to start at the site of the former Keene airport. Much of this land lies within Keene's flood plain areas, although they are not within Beaver Brook's flood plain.

The first residential area in Keene developed to the south and west of the CBD. Later development occurred to the east of Main Street along Beaver Brook, closer to the factories. Newer homes have been built in subdivisions located north and northwest of the CBD. Much of the land has been developed in low density single family homes. Multi-family units have located in the older sections of the city and to the north and west of the regional shopping centers.

Future residential development in Keene will follow past patterns. Therefore, new homes can be expected to be built to the north and west of the CBD with much of this development in low density single family dwellings. Many of the sites where medium and high density residential development is expected are within floodprone areas, south of the CBD. These developments may require floodproofing. Any flood plain development would be exceptions to the city's policy of locating new housing development outside of the flood plain. None of the floodprone sites, however, are located in the Beaver Brook flood plain.

Major goals established in 1977 for future land use development call for the maintenance of the city's distinctive rural character by preserving at least 50 percent of the city's land as open space. The Conservation Commission has been responsible for purchasing land toward meeting these goals. Those lands have generally been ones in immediate danger of development.

By the year 2000 land devoted to urban uses is expected to increase 55 percent and acres actively farmed are expected to decrease 48 percent. It is anticipated that by 2000, 43 percent of the city's land will be developed, compared with 36 percent in 1979. Low density residential development is expected to contribute the largest increase in urban development.

There appears to be ample land in the city to meet demands for development for a variety of uses between now and 2030. However, there will be development pressures on flood plain areas for industrial and commercial uses.

Twenty-three percent of Keene's suitable vacant land is contained in parcels which lie wholly or partially within the boundaries of the 100-year flood plain. These floodprone areas include 46 percent of the land available for industrial development, and 27 percent available for commercial uses.

d. Flood Plain

Beaver Brook flows through the residential section on the east side of Keene. Many older owner-occupied residences and small neighborhood stores are located in the Beaver Brook flood plain. The brook passes through the older industrial section of Keene (south of Roxbury Street) and flows by the Princess Shoe Building, an old brick structure that now houses small retail and industrial firms. The largest plant in the flood plain is that of the Kingsbury Machine Tool Corporation facility, located over and adjacent to Beaver Brook near Laurel Street. To the south of Marlboro Street, the brook flows through a medium density residential area and then joins the Branch just below Route 101. Much of Keene's original industrial acreage lies within the Beaver Brook flood plain. The intensity of existing development negates the potential for significant future development.

Housing types in the flood plain are varied. North of George Street (north of the city center) most of the homes are smaller, single-family units. Between George and Water Streets, the homes are large single-family units on small lots, built between 1870 and 1910. Interspersed with manufacturing and industrial uses, many of these units have since been converted into apartments. The area between Marlboro Street and Route 101 also contains large single-family units; some of which have been converted to apartments.

V. Impacts of the Proposed Action and Alternatives.

Project impacts to the existing natural, historical/archeological, and socioeconomic resources are discussed below for each alternative plan, including "no action". The discussion is summarized in Table 3 which appears at the end of this section.

A. Plan A. The Structural Plan and Recommended Plan

1. Impacts to Natural Resources

Plan A would impact on the natural resources of the two project areas: Three Mile Swamp and the downtown Keene channel between Water and Marlboro Streets. Impacts to both areas would be short term and long term in nature.

a. Three Mile Swamp.

The short term impacts at Three Mile Swamp would be generally associated with the proposed construction activities at the site. These include: (1) lowering of the existing impoundment to dewater the dike work area; (2) placement and removal of steel, earthen, and/or concrete cofferdams for the temporary diversion and dewatering of the dam work site; (3) excavation of the existing stone dam, temporary diversion channels, and upland and riparian areas upstream and downstream of the dam; (4) construction of the new concrete outer structure and stilling basin; and (5) construction of the earthen dike on the west bank of the wetland upstream of the outlet.

Activity (1) involves the temporary lowering of the existing pond elevation about two vertical feet for a 4-5 month period probably from April to July or August. This would reduce the areal extent of the existing pond and expose the normally water-covered bottom sediments on the pond's periphery to the atmosphere. This exposure would eliminate the benthic vegetation and animals (rooted plants, benthic algae, benthic invertebrates such as crustacea or insects) associated with the sediments. Lowering of the pond would also lower the water table around the wetland periphery which could isolate some areas of aquatic vegetation and reduce the water-dependent plant and animal habitat in these areas, especially during the dry season. As soon as the necessary stripping of the existing bank and construction of the dike is completed, the original water level would be restored. Plant and animal productivity of the remaining habitat should be reestablished during the following growing season.

It will also be necessary to divert the normal streamflows away from the existing outlets to allow excavation of the existing dam and adjacent areas and the construction of the new outlet and stilling basin. Placement of the cofferdams would divert inflows away from the work site for a distance of about 200 ft. downstream of the dam. As indicated above, the dewatering of the work site would expose the benthic habitat in the impoundment and stream bed and would temporarily reduce the plant and animal productivity of these areas for the duration of the construction and recovery periods. Placement of the cofferdams would also bury existing benthic plants and animals in the 6200 square foot area of the streambed. Once the construction of the new outlet and stilling basin are completed, and the cofferdams are removed, normal flows would be restored

and the benthic areas would repopulate. Activities (3-5) would involve earthmoving and construction activities on and around the work sites. The placement and removal of the cofferdams, excavation of the bank and bed areas, and the placement of the fills involve the use of heavy machinery. Such activities would involve increases in noise and dust in the work area and siltation into the downstream aquatic habitat. Noise and dust and general activity would probably restrict wildlife use of the area to urban associated species which are more tolerant to human activity. It is anticipated that wetland-associated species would return after completion. The increased stream siltation would temporarily degrade water quality by increasing the turbidity, suspended and dissolved solids, nutrients and biological oxygen demanding substances in the water. This would probably impact the downstream aquatic organisms by temporarily reducing the species diversity and standing crops. Such impacts have been noted by Cordone and Kelly (1961), Chutter (1969) and Gammon (1970). However, the above described dewatering of the construction sites should minimize the amount of fine materials that would enter the water. In addition, hay bales, filter cloths or other silt controlling measures would be used as appropriate to minimize silt deposition that would be derived from erosion of the unprotected soils. Once construction activities are completed the downstream organisms should repopulate areas depleted by the limited siltation that would occur.

The proposed work at Three Mile Swamp would also have long term impacts on the natural resources of the swamp.

As indicated above, placement of the outlet structure, stilling basin and the dike would involve the loss of upland, wetland and riparian habitat in the vicinity of the dam site. In total, about two acres of existing habitat would be permanently removed. Placement of the new outlet and stilling basin would require removal of about 0.75 acres of upland and riparian habitat downstream of the dam. Construction of the dike would require removal of 0.5 acre of wetland and 0.75 acres of upland on west bank upstream of the dam.

The lost habitat would be displaced by the flood control structures and, therefore, would not be totally restored. However, none of the described habitat is unique or more than locally significant and represents a small percentage of the total habitat available to species. For example, the lost wetland acreage is only about 2% of the total ponded area of the swamp. A large amount of available wetland habitat also occurs above the impounded area along Beaver Brook and on the other side of Route 10. The same is true for upland habitat.

The displacement of the existing habitat by the flood control structures would permanently change the habitat characteristics. The quality riparian and upland habitat downstream of the outlet would be replaced with the concrete stilling basin and the stone-lined excavated channel which would tie in with the existing stream. This "new" reach would be exposed to the sun which would probably result in a warming of

the water temperatures particularly during the summer low flow periods. A V-shaped channel would be built into the reach to maintain water depths, thus reducing impacts to the water quality and accommodating the passage of fish. As mentioned above, the upstream area is stocked by the State of New Hampshire with brook trout which are intolerant to warm water conditions (Carlander, 1969). However, the stocked individuals are usually harvested or have moved to the downstream area by the time the water becomes warm. Thus, based on the present stocking levels and conditions, a slight increase in the water temperature should not be significant. The existing stream does provide a good variety of natural microhabitat that contribute to the productivity of the stream. The loss of this productivity would be partially offset by the microhabitat created by the stone lining in the channel. The level of productivity, however, would not be as high nor would the population be as diverse as the existing community.

The wetland and upland habitats upstream of the outlet on the west bank would be replaced by the new dike. The toe of the dike on the wetland side would be made up of stone fill. The landside portion of the dike would be planted with tall grasses. Thus, neither the wetland or upland habitats in this area would be replaced. However, as mentioned above, neither habitat is particularly significant and both represent a small percentage of the available habitat in the area.

Another long term impact associated with the proposed Three Mile Swamp development is the increased utilization of flood storage afforded by the new outlet structure. During the Standard Project Flood the swamp would store flood waters up to elevation 797 ft. NGVD, which is about 10 vertical ft. above the existing pond elevation. The upland habitat adjacent to the wetland on the east bank would be inundated during flood events. Since flood storage at this level would not be longer than 48 hours, no impacts are anticipated to the upland vegetation. Certain wildlife species that may be using the habitat during a flood event would be displaced or perish from the rising waters. The area does provide good nesting habitat for black ducks which may nest along the wetland perimeter during May and June. If a flood storage event occurs during this time, a nest may be inundated by the rising waters. Studies by Coulter and Miller (1968) have indicated that black ducks may renest if their first nesting is destroyed. Otherwise, a nesting pair may not sucessfully nest that particular year.

Another long term impact is the change in aesthetic value of the wetland after construction. The proposed project would remove all existing shoreline vegetation on the highway side of the reservoir for a distance of 1100 feet upstream of the existing dam. The dike constructed in this area would be grass covered on the highway side and rock faced on the water side. Due to the gradient of the highway, the height of the dike would decrease from 7 feet above the highway at the dam to meeting existing ground at its upstream end, 1100 feet to the north. The view of the existing water and wetland for persons in passing vehicles would thus be obstructed for more than 600 feet by a grass covered slope.

To construct the proposed spillway and discharge channel, the existing rubble stone dam and all vegetation in a 15,000 square foot area below the dam will be removed. Clearing would remove all vegetation up to the grass covered highway shoulder for a distance of 180 feet downstream of the dam. This opening will make the proposed concrete dam readily visable from the highway. The discharge channel will be either exposed bedrock or a stone blanket.

b. The Downtown Keene Channel

The proposed channel reconstruction of Beaver Brook in the downtown Keene area would impose short and long term impacts to the natural resources of the area. As described in the previous section, the short term impacts are generally related with construction activities at the site. The work involves excavation of the stream bank and bed habitat in the 1750 ft. reach between Marboro and Water Streets and the placement of fill to stabilize the new channel. These activities would cause increased noise and dust in the work areas and siltation in the stream. As mentioned above, these impacts would continue throughout the period of construction and would cease when activities are completed. The increased siltation would temporarily degrade the existing water quality of the brook by increasing the turbidity, suspended and dissolved solids, nutrients and biological oxygen demanding substances. This impact would be mitigated by silt control measures such as the placement of hay bales to limit the siltation from the work area and to reduce its effects downstream. The action would make the reach of the stream unsuitable for fish habitat during the construction period. Anglers who use this area for access to Beaver Brook would have to use other designated fishing areas until construction is completed.

The long term impacts would involve the loss of existing riparian habitat in this reach of Beaver Brook. A total of about 0.75 acre of upland/stream bank area would be removed. This impact is generally lessened by the highly developed and altered nature of the brook throughout most of the reach. The bank vegetation is generally sparse except for a few areas, such as along the west bank north of Marlboro Street where development has not encroached the bank. About 0.5 acre of the total affected upland/streamside area is vegetated. Loss of this habitat particularly the shrubs, would reduce the area's attractiveness to residential urban wildlife. Vegetation on the bank would be replaced by a stone lining on the lower portion and flood tolerant grasses on the upper portion. This would replace some of the lost grassy areas but would be of limited use to local wildlife which would probably use other available reaches of the bank.

The proposed construction would also remove about 0.5 acre of the existing stream bank habitat in this reach. This loss is not significant because the stream bottom of this reach of the brook generally offers little food or cover to aquatic species. The area would be replaced by a stone-lined channel which could provide a limited number of microhabitats for stream associated plants and animals.

Widening of the stream bottom would probably slightly increase the water temperatures of the brook during summer low flow periods. However, the project design would incorporate a deeper V-shaped channel in the center of the reconstructed bottom to maintain water quality and fish passage. Water depths would be at least 1 foot.

Widening of the channel would also permanently lower the water table around the area of the brook. Potential effects would be considered minor because of developed nature of the adjacent areas.

The proposed channel work in the city of Keene would also alter the visual character of approximately 1750 feet of Beaver Brook. This section of the brook flows through a highly industrialized area with very little significant vegetation other than tall grass and naturalized shrub growth. The brook has been greatly altered by channelization and adjacent construction. The proposed work would replace the streambed and part of the adjacent banks with stone protection (riprap) to a uniform height above the streambed. The upper portion of the bank would be replanted with tall grass similar in visual character to existing vegetation. The result will be a visually uniform channel.

2. Impacts to Historical/Archeological Resources

The downtown portion of this plan occupies an area heavily modified during the historic period, and intact prehistoric resources are highly unlikely. Historic period resources are limited to retaining walls and bridge abutments of little historic or engineering significance.

The Three Mile Swamp portion of this plan may have been an area of prehistoric hunting activity, but an archaeological reconnaissance of the area (included in supporting documentation) did not reveal any resources of significance. The only historic period resource in this area is a fieldstone and earth dam with no associated features and little historic or engineering significance. In view of the above findings, Plan A is unlikely to affect historic or archaeological resources eligible for the National Register of Historic Places.

3. Impacts to Socioeconomic Resources

Plan A, involving structural activities at Three-Mile Swamp and downtown Keene (between Marlboro Street and Water Street) would reduce flood damages along Beaver Brook over the long term. Although not capable of greatly modifying rare events, the project would be designed to reduce damages from "minor" flooding events, that occur on an almost yearly basis. With the reduction in flood damages would come some reduction in non-physical losses, such as business closings and cleanup activities that would be associated with a post-flood period. Structures benefiting directly from the project include a mix of homes and businesses along the brook. The project would not affect any significant land use changes within the flood plain over the long term.

Construction of a new outlet structure at Three-Mile Swamp would permanently alter the existing aesthetics. The swamp is presently restrained by an old stone wall dam in disrepair, in a lightly forested area. Although within view of Route 10, the area is undeveloped, and offers a pleasing scene. The project would eliminate the stone dam and replace it with a stepped spillway structure with a maximum height of 17 feet. A dike would run along Route 10 for a distance approximating 1100 feet, where it would tie into high ground. The dike would be grassed from the highway side, although any view of the wetland area from the road would be greatly reduced. The dike would be riprapped from the swamp side. The channel work, on the other hand, would minimally affect the aesthetics in the downtown area.

The short term impacts associated with construction activities would be experienced in both the Three-Mile Swamp area and the downtown area. The dam and dike construction at Three-Mile Swamp is expected to take 6-9 months. During this time the area would be subjected to heavy truck travel and movement of equipment and materials. Although the site is easily accessible from Route 10, the construction activity may hinder normal traffic flow during the construction period. The effect is expected to be minor. The dam and dike would present an imposing appearance in a somewhat undisturbed area, and restrict visibility of the swamp from the road.

Construction activities in the channel in the downtown area could also prove disruptive to the normal activities, particularly to the narrow roads that already carry significant numbers of trucks. Again this effect would be temporary, lasting one construction season. Residents as well as workers would be subjected to some increase in noise and dust levels.

B. Plan B, The Nonstructural Plan.

1. Impacts to Natural Resources

Since this alternative plan involves no structural or physical change in the project area, no impacts would occur to the existing natural resources of the area.

2. Impacts to Historical/Archeological Resources

As this plan is non-structural, no effect upon archaeological or historic resources is anticipated.

3. Impacts to Socioeconomic Resources

Plan B provides for a nonstructural plan, an automated flood forecasting and warning system. With limited implementation impacts, the plan can provide some flood protection over the long term. Flood plain occupants available to heed a floodwarning would be offered a period of 1-3 hours to rearrange or remove contents of their homes or businesses to

reduce potential flood damages. A review of damage survey sheets indicates that losses to movable residential contents, i.e. small appliances, clothes and food, make up about 10 percent of the physical losses experienced in a home. It is estimated that half of these losses can be saved by a warning system. A reduction in these losses should also save some cleanup time resulting in more rapid resumption of normal activities. Some reduction in commercial and industrial losses can also be expected.

Implementation of the floodwarning system would require a location manned 24 hours daily to assure the receipt of the warning for dissemination. In addition, the location should be outside the flood plain and have an auxiliary power source. No significant administrative problems are anticipated with the implementation of this system. The city would be responsible for a plan by which to disseminate the warning and if necessary evacuate residents.

C. Plan C, The Combination Plan.

1. Impacts to Natural Resources:

The impacts of this alternative plan would be the same as described previously under Plan A.

2. Impacts to Historical/Archeological Resources

This plan is expected to have no effect upon significant historic or archaeological resources, for the reasons outlined in the discussions of Plans A and B.

3. Impacts to Socioeconomic Resources

Plan C combines the structural features of Plan A with the non-structural elements of Plan B. Therefore, impacts of Plans A and B can be combined to indicate those for C.

D. The "No Action" Alternative

1. Impacts to Natural Resources

The "no action" alternative means that no structural or non-structural flood control measures would be implemented at Three Mile Swamp or in the downstream Keene area. No impact to the natural resources would occur at the project sites. Flooding would continue as it has in the past. The future fish and wildlife use of the project is not expected to significantly change from existing conditions.

Table 3. Summary of Impacts of the Proposed Action and Alternatives

| Alternative | Plan A | | Plan B | Plan C | Plan D |
|---|---|---|---|---|---|
| | Long Term | Short Term | | | |
| **Natural Resources** | | | | | |
| Wetlands | Excavation of 0.5 acre wetland soils and vegetation. | Temporary dewatering of wetland periphery; lowering of water table around wetland; increased noise, dust, siltation during construction period. | No impact | Same as Plan A | No impact |
| Upland/Streambank | Excavation of 2.0 acres of upland soils & vegetation increased flood storage at higher elevations; contouring of bank slopes. | Increased noise and dust during construction period. | No impact | Same as Plan A | No impact |
| Streambed | Excavation of 0.5 acre of existing streambed habitat; would be replaced with larger stone fill or bedrock substrate; contouring of stream bottom to maintain water quality. | Temporary dewatering; Increased noise, dust, siltation. | No impact | Same as Plan A | No impact |
| Water Quality | Slight increase in stream water temperatures. | Increased suspended and dissolved solids, turbidity, nutrients, BOD during construction period; dewatering work sites and siltation control measures would reduce this impact. | No impact | Same as Plan A | No impact |
| Fish/Wildlife | Loss of above habitats; access to stream would be reduced; potential inundation of habitat during flood storage. | Degradation of habitat during construction period. | No impact | Same as Plan A | No impact |
| Historical/Archeological Resources | No impact | No impact | No impact | No impact | No impact |
| **Socioeconomic Resources** | | | | | |
| Noise | No impact | Minor increase during construction | No impact | Same as Plan A | Continuation of existing conditions |
| Aesthetics | Obstruction of view along Rt. 10 with dike. | Minimal during construction | No impact | Same as Plan A | Continuation of existing conditions |
| Transportation | No impact | Some localized congestion | No impact | Same as Plan A | No impact |
| Health/Safety | Improvement with reduced flooding | Minor threat at construction sites | Improved by advance warning | Same as Plans A & B | Continuation of existing threat |
| Employment | No impact | Minor increase during construction | No impact | Same as Plan A | No impact |
| Business Activity | Improved with reduced nuisance flooding and subsequent cleanup. | No impact | Improved preparedness by flood warning to move damageable contents. | Same as Plans A & B | No impact |

2. Impacts to Historical/Archeological Resources

If no action is taken, there will be no effect upon historic or archaeological resources.

3. Impacts to Socioeconomic Resources

The without project scenario reflects conditions that for the most part are a continuance of existing conditions. Without a project, "nuisance" flooding on an annual basis would continue to occur as would less frequent events. Damages to residential and other flood plain users would continue unchecked.

The Beaver Brook flood plain is not expected to undergo any significant land use or growth changes. For the most part, this is due to the lack of suitable areas for development.

## VI. Coordination

### A. Public Involvement

This project is being planned by the Corps of Engineers in coordination with other Federal, State and local concerns. With regard to environmental matters, a number of agencies and individuals have been consulted or have supplied this office with information for development of this study. Pertinent written correspondence may be found in Appendix 1 of this report.

| | |
|---|---|
| Mr. Edwin Robinson, | U.S. Fish and Wildlife Service |
| Mr. Fred Benson, | U.S. Fish and Wildlife Service |
| Mr. Richard Dyer, | U.S. Fish and Wildlife Service |
| Mr. George Morrison, | New Hampshire Fish and Game Department |
| Mr. Carl Lacaillade, | New Hampshire Fish and Game Department |
| Mr. Donald Greenwood, | N.H. Water Supply and Pollution Control Commission |
| Dr. Gary Hume, | N.H. Department of Resources and Economic Development (Historic Section) |

This draft report is being issued to the following agencies for review. Comments on this document will be considered in preparation of the final report.

U.S. Environmental Protection Agency, Washington D.C.
U.S. Environmental Protection Agency, Region I, Boston MA
U.S. Fish and Wildlife Service, Concord N.H.
U.S. Department of Health and Human Services, Boston MA
U.S. Department of Housing and Urban Development
U.S. Department of Energy, Region I, Boston MA
New Hampshire Department of Resources and Economic Development, Concord NH
State Office of Comprehensive Planning, Concord NH
New Hampshire Water Supply and Pollution Control Commission, Concord NH

New Hampshire Fish and Game Department, Concord NH
New Hampshire Water Resources Board, Concord NH
National Audobon Society, Sharon CT
Sierra Club, Hanover NH
Federated Sportsmen Club of New Hampshire, Concord NH
Society for Protection of New Hampshire Forests, Concord NH
National Wildlife Federation, Washington D.C.

B. Compliance with Environmental Protection Statutes

1. Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469 et seq. *N/A

2. Clean Air Act, as amended, 42 U.S.C. 7401 et seq. Review of this Assessment will constitute compliance with this Act.

3. Clean Water Act (Federal Water Pollution Control Act), as amended, 33 U.S.C. 1251 et seq. Review of the attached 404(b) Evaluation will constitute compliance with this Act.

4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451 et seq. N/A

5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq. The U.S. Fish & Wildlife Service has determined that no Federally listed endangered species occur in the project area. Review of this Assessment will determine if this Act is being complied with.

6. Estuary Protection Act, 16 U.S.C. 1221 et seq. N/A

7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 et seq. Review of this Assessment by the Department of Interior will constitute compliance with this Act.

8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 et seq. Review of this Assessment will constitute continuing compliance with this Act.

9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 et seq. Review of this Assessment by the Department of Interior will constitute compliance with this Act.

10. Marine Protection, Research and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 et seq. N/A

*N/A - Not Applicable

11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. Review of this Assessment will constitute continuing compliance with this Act.

12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 432 et seq. Review of this Assessment will constitute continuing compliance with this Act.

13. Rivers and Harbors Appropriation Act of 1899, as amended, 33 U.S.C. 401 et seq. N/A

14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 et seq. N/A

15. Wild and Scenic Rivers Act, as amended 16 U.S.C. 1271 et seq. N/A

## VII. References Cited


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Chutter, F.M. 1969, The Effects of Silt and Sand on the Invertebrate Fauna of Streams and Rivers. Hydrobiologica 34:57-76

Cordone, A.J. and D.W. Kelley 1961, The Influences of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47:189-228

Coulter, M.W. and W.R. Miller 1968, Nesting Biology of Black Ducks and Mallards in Northern New England. Vt. Fish and Game Bull. 68-2. 74 pp.

Gammon, J.R. 1970, The Effect of Inorganic Sediment on Stream Biota. GPO publication prepared for Environmental Protection Agency 144 pp.

Section 404(b)(1) Evaluation for the
Beaver Brook Flood Damage Reduction Project

1. References

a. Section 404(b)(1) of Public Law 92-500, as amended, Clean Water Act.

b. 40 CFR Part 230 Subparts B, C, D, E, F, G, and H dated 24 December 1980.

c. EC-1105-2-104, Appendix C, dated 30 September 1980.

d. ER 1105-2-50, Appendix F, dated 29 January 1982.

2. Project Description

a. General Description

Structural flood control measures are proposed for Keene, New Hampshire along Beaver Brook. A new floodwater retarding structure would replace an existing stone dam at the outlet of an upstream wetland called Three Mile Swamp. Also channel improvements are proposed in the downtown Keene area for Beaver Brook between Marlboro and Water Streets.

The new dam at Three Mile Swamp would have an ungated stepped concrete spillway with an non-overflow section constructed to elevation 799 ft. National Geodetic Vertical Datum (NGVD). The stepped spillway is designed to maintain the existing pool elevation during non-flood periods and provide some surcharge storage during a flood. During the Standard Project Flood, the pool behind the dam would rise to elevation 797 ft. NGVD for a duration of less than 48 hours. In order to maintain control of the floodwaters at the dam, a 12 ft. high earthen dike would be constructed along the west bank of the wetland to prevent overflows on Route 10 which parallels the bank. Placement of the modified dam would also involve the construction of a stilling basin downstream of the dam spillway and tapering of the channel width from the 200 ft. spillway width down to meet the existing channel width downstream. The proposed channel improvements for Beaver Brook in downtown Keene involve widening the channel and banks to obtain an even slope and width of the brook throughout its reach. The channel width would be increased to 17 ft. and lined with riprap to a vertical height of 4 ft. above the invert. Grasses would be planted on the upper bank for stabilization. The channel bottom would be graded to create a deeper channel center for maintenance of water quality and fish passage during summer low-flows.

A more detailed project description may be found in the Description of Alternative Plans Section of this Detailed Project Report.

b. Authority and Purpose.

The project is proposed under the authority of Section 205 of 1948 Flood Control Act, as amended. The purpose of the project would be to provide flood protection to the city of Keene for frequent and lower stage events.

c. General Description of the Fill Material

1. 1000 cubic yards (c.y.) of random fill to be derived from nearby upland sites.

2. 1700 cy of concrete from local distributors.

3. 1880 cy of gravel from a nearby clean source.

4. 3550 cy of quarry-cut angular stone with median sizes ranging from 12-15".

5. Preformed concrete slabs and steel sheet cofferdam material.

d. Description of the Proposed Discharge Sites

The proposed work would involve discharge of the above fill in temporary and permanent locations, which are exhibited on Plates 1-8.

1. Temporary Disposal Sites:

Concrete slabs, steel sheets and about 1000 cy of random fill would be deposited at the cofferdam sites indicated in Plate 5. The discharge would displace about 6200 square feet of the pond and 120 sq. ft. of river bottom habitat. This disposal would occur early in the construction period and would be removed when construction activities are completed.

2. Permanent Disposal Sites.

Permanent disposal sites include the wetland and streambed at Three Mile Swamp and the streambed in the downtown Keene reach of Beaver Brook.

The sites at Three Mile Swamp would be filled as a result of construction of the new dam, stilling basin and the dike. The existing stone dam would be replaced by a new concrete structure which would involve the placement of 1700 cubic yards of concrete in 3200 square foot area (Plate 4). The stilling basin below the dam would require the placement of 50 cy of concrete and 100 cy of stone and gravel in a 1000 square foot area of streambed (Plate 4). Construction of the dike would require the deposition of 2250 cy of gravel and stone fill in about a 0.5 acre of the pond and its peripheral wetland habitat.

The channel improvement in the downtown Keene involves about 4400 cy of stone and gravel fill in about 21,000 square foot area of streambed (Plates 8-10). Discharge of the above fill would occur intermittantly throughout the period of construction.

e. Description of Disposal Method.

The fill would be deposited with use of a backhoe or a crane mounted on the dewatered bank areas.

3. Factual Determinations (Section 230.11)

a. Physical substrate determinations.

The proposed work involves the placement of temporary and permanent fill in the wetland and streambed habitats at Three Mile Swamp and in the streambed habitat in the downtown Keene reach of Beaver Brook.

The proposed fill for the cofferdams would temporarily change the character and topography of the existing pond and streambed substrates for the duration of the construction period (about 7-8 months). The disposal would bury benthic plants and animals within the discharge area. Once the material is removed, the substrate of areas not altered by permanent fill would be restored. About 6200 square feet of the wetland and 120 square feet of streambed would be affected.

Approximately 0.5 acre of organic substrate in the pond and its peripheral wetland and a 0.5 acre of total stream bottom would be replaced with stone and gravel fill. This new substrate would not be suitable for wetlands and the affected 0.5 acre would be permanently removed. Changes in the streambed substrate would be less severe because of the already rocky nature of the stream bottom. However, the quality of the new fill, in terms of partical size and shape, would permanently alter the character of the stream. The larger angular stone would provide fewer stream microhabitats and hence be less productive than the existing streambed. This impact would be less severe in the downtown Keene reach because of its already altered condition. The channel would be widened to accomodate high flows during flood events. The channel center would be deepened to maintain water quality and downstream aquatic habitat.

b. Water circulation, fluctuations and salinity determinations.

The placement of the cofferdams would temporarily divert stream flows and dewater normally wetted areas during the construction period. The flows and pool levels would be restored when the proposed work is completed. The proposed fill activities, particularly the disposal of random fill, would cause temporary increases in nutrients and loss of clarity in the pond and brook waters. These impacts would cease when the proposed filling is completed and should not contribute to the

eutrophication of the waters. Widening of the channel would probably lead to a slight increase in water temperature during low flow periods. However the center of the channel would be deepened to maintain water quality and fish passage during low flows.

c. Suspended particulate/turbidity determinations.

The proposed discharge of 1000 cy of random fill for the cofferdams at Three Mile Swamp would cause temporary and restricted increases of suspended and dissolved solids in the pond and brook waters. The New Hampshire water quality standards are 10 standard turbidity units for Class B waters supporting a coldwater fishery. An estimate of the anticipated turbidity levels from the discharge of random fill is not practical. However, turbidity levels from such a discharge wuld probably exceed state standards for discreet periods during the construction period - mainly during deposition and removal of the cofferdams. The impact would be a short-term phenomenon and should not have a significant effect on the aquatic ecosystem. In addition, the areal extent of the impact would be restricted to the immediate work area by downstream silt control measures such as hay bales in the brook. Thus the downstream water quality should be protected. The discharge of other temporary and permanent fill such as steel sheeting, concrete and riprap would probably cause only minor increases in turbidity levels in the work area because of the solid nature of the materials.

d. Contaminant determinations.

The fill used for the project would be derived either from the project area or another nearby clean source. Other than small increases in suspended and dissolved solids, some nutrients and biological oxygen demanding substances, little or no increases in contaminants derived from the fill material are anticipated.

e. Aquatic ecosystem and organism determinations.

The loss of the aquatic habitat and plant and animal productivity from placement of the cofferdams are temporary and would be restored after the construction and recovery periods. In the long term, the wetland and aquatic habitat displaced by the stone fill would not be restored. The deposited stone in the streambeds would provide a limited number of stream microhabitats for benthic plants and animals. However, the quality of this habitat with respect to substrate particle size, circulation, riffle/pool development and vegetation would be less valuable to benthic organisms. Thus, the original productivity levels would not be reestablished. This impact would be less noticeable in the downtown reach of Beaver Brook where the habitat is already severely altered.

f. Proposed disposal site determinations.

The mixing zone determinations is not applicable to this project.

g. Determinations of Cumulative effects on the aquatic ecosystem.

The cumulative effect of the proposed discharge would be the effective removal of 0.5 acre of wetland and 0.5 acre of streambed habitats. This loss would not significantly effect the ecosystem as a whole because of the availibility of like habitat and productivity in other nearby areas.

h. Determinations of secondary effects on the aquatic ecosystem.

The increase in storage of the pond behind the proposed Three Mile Swamp dam during flood events would temporarily inundate or displace wildlife habitat in and around the pond's periphery. The storage would not be held longer than a 48 hr. period and should not have an adverse impact on the area's vegetation. Thus, the storage should not cause any significant long term effects on habitat.

IV Findings of Compliance (Section 230.12)

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. There are no practicable alternatives to the proposed discharge site which would have less adverse impact on the aquatic ecosystem. The development of other sites downstream of the Three Mile Swamp would involve more disturbance of existing habitat and more extensive road relocations. The use of other structural measures at the Three Mile Swamp were not considered practicable within the funding constraints of this project.

c. The proposed discharge of riprap, concrete and steel sheet fill materials would comply with applicable State Class "B" water quality standards. The discharge of the random fill in the pond may cause short term and restricted increases in turbidity. The disposal operations will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. Use of the disposal site will not harm any Federal listed threatened or endangered species or their critical habitats.

e. The proposed disposal of dredged material will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing,

plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic and economic values will not occur.

f. Appropriate steps to minimize potential adverse impacts of the discharge on the aquatic systems include dewatering of work sites and appropriate silt control measures such as hay bales.

g. On the basis of the guidelines the proposed disposal site for the discharge of fill material is specified as complying with the inclusion of appropriate and and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

h. Placement of fill material is expected to improve the human and econmic environment by reducing flooding and improving the local residential and urban business climate.

The proposed sites for the placement of flood control measures along Beaver Brook in Keene, NH has been specified through the application of Section 404(b)(1) Guidelines.

The project files and Federal regulations were reviewed to properly evaluate the objectives of Section 404(b) of Public Law 92-500, as amended. A public notice with respect to the 404 Evaluation will be issued accompanying this document. Based on information presented in this Section 404 Evaluation, I find that the project will not result in unacceptable impacts to the environment.

Carl B. Sciple
Colonel, Corps of Engineers
Division Engineer

## ACKNOWLEDGEMENTS

This report was completed by the New England Division, Army Corps of Engineers, under the general direction of Colonel Carl B. Sciple, Division Engineer. It was prepared by Ms. Karen Liska, Project Manager, under the overall direction of Mr. William Swaine, Chief, Plan Formulation Branch, Mr. Nicolas E. Avtges, Deputy Chief, Planning Division, and Mr. Joseph L. Ignazio, Chief, Planning Division.

Members of the study team included:

| | |
|---|---|
| Ms. Diana Halas | Impact Analysis Branch |
| Mr. David Tomey | Impact Analysis Branch |
| Mr. John Wilson | Impact Analysis Branch |
| Mr. Mark Geib | Water Control Branch |
| Mr. Raymond Crump (ret) | Engineering, Design Branch |
| Mr. Bill Herland | Engineering, Design Branch |
| Mr. John Hart | Geotechnical Engineering Branch |
| Mr. Ed Fallon | Real Estate Division |

# APPENDIX 1

# PUBLIC INVOLVEMENT

# APPENDIX 1
# PUBLIC INVOLVEMENT

## ATTITUDE SURVEY

To aid in identifying acceptable measures of flood control, two surveys of public attitudes were conducted in Keene during the previous investigation, under the direction of a committee of local citizens. In the first survey, residents living in both the city's flood plain and in other areas were randomly selected and interviewed to reveal their perceptions of the flood problem and their opinions on ways to reduce damages. In the second survey, members of Keene's business community, local, State and Federal officials, members of certain city boards (i.e. those with an interest in the management of Keene's flood plain) were interviewed in a less structured fasion. These interviews concentrated on land use and community development issues as well as attitudes toward specific alternatives.

### Resident Survey

To establish a perspective of residents' attitudes toward flood protection measures, residents were questioned about personal experiences with flooding and the seriousness of the flood problem in Keene.

Fourteen types of measures to reduce damages from flooding were covered in the survey. Respondents were questioned as to their familiarity with each alternative, whether or not they thought each alternative would be effective in reducing flood damages, and whether or not they thought that the alternative should be used in Keene.

#### Perception

Of the 198 respondents, 86 indicated that they have lived in a place where there was a flood. Although some respondents reported flood experiences from previous residences in other areas, most respondents were familiar with flooding in Keene. Half of those who indicated having experienced a flood, reported some type of damage. Thirty respondents reported property damage, 13 financial losses, and 2 personal injuries.

More than half (57 percent) of the people interviewed believed that flooding has been a very serious or somewhat serious problem for Keene in the past. Survey results reveal that fewer respondents felt that flooding would continue to be serious.

#### Familiarity

Measures were ranked as to their familiarity to residents. Dams, disaster relief, and dikes were ranked the most familiar, being recognized by more than 90 percent of the respondents. Alternatives familiar to at least two-thirds of the respondents in addition to the three mentioned

above include warning/evacuation, channel alterations, and flood proofing by elevating mechanical equipment. The least familiar measures were transfer of development rights and use of window shields.

Effectiveness

Of the 14 flood control alternatives, 7 were rated effective by over 75 percent of the respondents. Six additional alternatives were rated effective by at least 50 percent of the respondents. The remaining alternative, installation of window shields was generally felt to be inapplicable to the basement flooding experienced in Keene.

The two measures thought to be most effective were dams and disaster relief. Of the five alternatives thought to be the least effective, three were measures that were least familiar to the people interviewed. These measures are: the transfer of development rights, floodproofing by installing watertight doors and window shields.

Preference

Overall, disaster relief was the most highly preferred alternative and was ranked highest by both flood plain and non-flood plain residents. It was followed by dams, followed by warning and evacuation. Although disaster relief and warning and evacuation systems were not perceived as the most effective, humanitarian reasons may explain why they are most preferred.

The greatest opposition to an alternative was directed to the concept of raising foundations. Common reasons for opposing this alternative included the cost and effort required, as well as the appearance.

Table 1 lists the alternatives in descending order from the highest to the lowest percentages of respondents favoring a measure. Most importantly, it should be noted that all measures were favored by more than 1/2 of the respondents.

Table 1

RANKING OF ALTERNATIVES

| | PREFERENCE FOR USE IN KEENE | | | | |
|---|---|---|---|---|---|
| | TOTAL RESPONSES | FAVOR # | FAVOR % | OPPOSE # | OPPOSE % |
| Disaster Relief | 195 | 188 | 96.4 | 7 | 3.6 |
| Dams | 169 | 155 | 91.7 | 18 | 9.6 |
| Warning/Evacuation | 187 | 169 | 90.4 | 18 | 8.3 |
| Floodproofing/ Elevate Mechanical Equipment | 182 | 160 | 87.9 | 22 | 12.1 |
| Channel Alteration | 154 | 130 | 84.4 | 24 | 15.6 |
| Flood Insurance | 163 | 132 | 81.0 | 31 | 19.0 |
| Dikes | 158 | 119 | 75.3 | 39 | 24.7 |
| Flood Plain Zoning | 173 | 124 | 71.7 | 49 | 28.3 |
| Floodproofing/Landscaping | 167 | 114 | 68.3 | 53 | 35.6 |
| Transfer of Development Rights | 149 | 96 | 64.4 | 53 | 35.6 |
| Floodproofing/Watertight Doors | 157 | 100 | 63.7 | 57 | 36.3 |
| Land Acquisition | 172 | 109 | 63.4 | 63 | 36.3 |
| Floodproofing/Window Shields | 149 | 89 | 59.7 | 60 | 40.3 |
| Floodproofing/Raise Foundations | 166 | 96 | 57.8 | 70 | 42.2 |

Community Survey

Several groups of people in the business community and public sector were targeted for interviews. These groups included: owners and managers of businesses located in the flood plain, people in the financial, insurance, and real estate sectors, staff of city agencies involved in land development in the city, and staff of regional, State, and Federal government agencies with programs that affect flood plain management through the management of water resources or land development.

These interviews were more informal and less structured than the interviews of residents. Issures covered during the interviews included; perception of the flooding problem, measures taken to prevent damages, attitudes toward measures not currently used, and opinions about land use development throughout the city with particular focus on flood plain areas.

The opinions of the business community and public sector members appeared to be divided to some degree between those who participate in the city's decision making process and those who do not. Those people participating in the decision making process include executives or managers of Keene's larger firms or firms that are locally owned and having been doing business in Keene for a long time. These people tend to think of the flooding problem as it affects the city as a whole as well as their businesses.

Another grouping, consisting of real estate brokers and developers, are chiefly concerned with flood plain management as it affects Keene's future development.

Much opposition to dams was expressed. High costs relative to benefits, and feelings that acceptance of Federal funds would entail other Federal contraints to development were reasons for opposition. Those favoring a dam felt that such a project would provide a permanent solution.

Consideration of channel alterations raised mixed feelings, mostly based on their effectiveness. City officials felt that they were effective, some business people were uncertain. Realtors expressing opposition cited examples where flooding conditions at individual properties had worsened.

Floodproofing was positively received by all groups although there was some disagreement as to who should have the financial burden of implementing floodproofing measures.

Flood insurance generally was favored by all groups except for some real estate brokers, whose clients had to participate in the program, although had not been flooded during their tenure. It was pointed out that there had been some difficulty identifying which properties lie in a flood hazard area.

City officials expressed opposition to both flood plain zoning and land acquisition because it would restrict the economic return to the city via taxes. On the other hand, flood plain zoning would provide an opportunity for agriculture and recreation uses that are more appropriate for floodprone areas. In opposing land acquisition, city officials also indicated limited resources would reduce the potential for purchasing open space areas.

A warning and evacuation system was thought to be a useful measure worthy of consideration. Businesses expressed the need for earlier warning to move stock and to implement emergency preparedness measures. City officials thought the current system adequate; dissenting real estate interests did not feel that the city possessed the resources for a more formal system.

Disaster relief, especially aid from the Federal government, was favored by all of those who were interviewed.

In general then, city officials and participants in civic affairs favored measures which were perceived as having low expenses for individuals or the city, could be implemented by individuals, and would not hinder the economic development of the flood plain. Non-participants favored measures that would improve their own situation.

## PUBLIC COMMENTS

In August 1983 the Draft Detailed Project Report and Environmental Assessment was circulated for a 30-day public review period. During that time, Federal, State, and local agencies as well as interested individuals were given the opportunity to comment on the results of our study. Written comments received as a result of this review period, together with responses to these comments, are presented in the following section along with other pertinent correspondence.

PERTINENT CORRESPONDENCE

# CITY OF KEENE

NEW HAMPSHIRE 03431

November 24, 1980

Max B. Scheider
Colonel, Corps of Engineers
Division Engineer
Department of the Army
424 Trapelo Road
Waltham, MA 02154

Dear Mr. Scheider:

In response to your letter of October 30, 1980 please consider this letter to be an official expression of interest and request for the reconnaissance work necessary to the further study of structural improvements along Beaver Brook under the special continuing authority provided by Section 205 of the 1948 Flood Control Act as amended.

Your willingness to develop this project with us is most appreciated.

Sincerely,

Patrick MacQueen/ehl

Patrick MacQueen
City Manager

/ehl

cc: William Joslin
Jerry McCollough, City Planning Director
John O. Hird, Director of Public Works

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Colonel Carl B. Sciple
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

MAY 18 1983

Dear Colonel Sciple:

This is our Fish and Wildlife Report on the Beaver Brook Flood Damage Reduction Project, Keene, New Hampshire. It has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Your draft Detailed Project Report (DPR) addressed three alternative flood control plans for local protection of the Keene area. Plan A includes only the structural measures of Plan C. Plan B, a nonstructural alternative, proposes the installation of an automated flood warning system within the Beaver Brook basin. Plan C, your recommended plan, combines the nonstructural measures of Plan B with the following structural measures: (1) a modified outlet structure with a stilling basin and raceway, and an earthen dike at Three Mile Swamp; and, (2) channel modification of 1,750 feet of Beaver Brook in the downstown Keene area between Marlboro and Water Streets.

We understand that the existing earth and rock wall dam at Three Mile Swamp would be replaced with a concrete gravity dam. The self-regulating spillway would have a stepped configuration with an 8-foot width at elevation 787 feet NGVD (National Geodetic Vertical Datum), a 50-foot width at elevation 792 NGVD, and a 200-foot width at elevation 794 NGVD. This structure would temporarily store runoff in Three Mile Swamp during flood periods, but would maintain the existing water surface elevation of the wetland during non-flood periods. The stilling basin, excavated at the downstream toe of the dam, would extend along the full 200-foot width of the spillway. A stone-lined raceway would gradually taper down from the stilling basin to meet the existing stream channel 200-feet downstream of the dam. The non-overflow portion of the dam, elevation 799 feet NGVD, would be extended by an earthen dike for a distance of 1,100 feet upstream along the west bank of the wetland parallel to New Hampshire Route 10. Stone slope protection would be placed on the wetland side of the dike while the remaining face would be topsoiled and seeded.

Channel modification of Beaver Brook in the 1,750-foot reach between Marlboro and Water Streets would involve construction of a trapezoided channel with an average depth of 7 feet and a bottom width of 17 feet. The channel bottom would be layered with stone protection and sloped to the centerline to provide a water depth of about 1 foot during periods of low flow. The lower 4 feet of the channel side slopes would be layered with stone protection and the upper 3 feet would be seeded to flood-tolerant grasses.

The area downstream from the existing stone dam is densely forested and there are no associated wetlands. A dam placed somewhere between the old stone dam and the new highway fill (Route 9) would reduce or eliminate inundation of Three Mile Swamp and eliminate the need to replace public access if the dike along Route 10 is not needed. We will need additional detailed data, such as anticipated pond elevations, and frequency of flooding, to determine if this is a suitable alternate for the project study.

The downstream reach where the channel will be widened and deepened extends about 2,700 feet between Marlboro and Water Streets. The stream passes beside buildings of the Kingsbury Machine Tool and Die Company through most of the reach. The water quality is barely adequate, in the summer, to sustain fish life but common sucker, yellow perch, shiners and dace reside in and pass through the area. Sport fishing is probably confined to young people and the stream is important to them where they can reach it. The channel work should be planned to maximize, insofar as possible, the aesthetic value and use by local residents. We recommend that gabions be used along the banks and vegetation encouraged to shade the stream. A "U" shaped pilot channel should be included so the depth will exceed 12 inches during periods of low flow.

We have no objections to construction of a vertical slot dam, but we need more information on the frequency and duration of flooding at the proposed site and at the new site further downstream that we suggest as an alternate. Relocation of the dam further downstream is a preferred alternate because it would reduce inundation of Three Mile Swamp. Mitigation requirements will be assessed when we have a chance to determine the potential impacts on the wetland.

Public access, possibly a ramp and platform at the top of the proposed dike, should be restored so that the existing use can be continued. We recommend that the downstream channel work include a "U" shaped pilot channel, streambank revegetation, and public access.

We appreciate the opportunity to report on this project, and we will assist in your planning so that adverse impacts to fish and wildlife resources will be minimized. A fish and wildlife report will be prepared when you have advised us of the plan you select for construction, but we feel that another planning aid letter will be necessary to summarize our evaluation of the two sites when you provide detailed information on the proposed operations.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

JUN 23 1982

Dear Sir:

This letter is intended to aid in your study of flood control measures on Beaver Brook in Keene, New Hampshire. It is submitted in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). It supersedes our previous reports on the earlier proposal for a larger reservoir.

The twenty-five acre-Three Mile Swamp, which will comprise most of the flood storage pool, is a highly productive and attractive wetland area. It has several wetland types ranging from emergent wetland to scrub-shrub wetland and small patches of aquatic bed and forested wetlands. It supports chain pickerel, brown bullhead, yellow perch and various species of forage fish, such as shiners and darters. In the spring, a few trout may be found when they move downstream from the reach that is stocked by the New Hampshire Fish and Game Department. Beaver, muskrat, mink, otter, hare, and white-tail deer are among the mammals that reside in the swamp or include it in their daily range.

Some gamebirds, such as ruffed grouse and woodcock, can be hunted in and around the swamp during the season. Many species of songbirds visit or reside in the swamp including redwing blackbird, tree swallow, kingbird, crow, a variety of warblers, and hawks and owls on occasion. The swamp is a scenic area, visited by many motorists who pull off Route 10 to view the wildlife. The proximity of the road and the frequent use does not seem to reduce wildlife activity.

Your plan to maintain the existing water level, except for flood storage, will confine adverse impacts to flood periods. The increase in pool level caused by flood storage should not have permanent adverse impacts on fish and wildlife unless the floodwater is held for more than several days during the spring and summer season. Flooding could destroy waterfowl and songbird nests during late May and June and cause the loss of less tolerant vegetation. Additional information on the expected frequency, duration, and elevation of flood storage is needed to make a detailed analysis of potential impacts.

The dominant vegetative species include speckled alder, dogwoods, red oak, red maple, and white pine. In the wetter sites, sedges, pond lillies, cattail, and potomogetons are found. These species have high tolerance to flooding, but species such as white pine and red oak can survive only short periods of inundation.

Nonstructural measures consist of installation of a fully automated flood forecasting and warning system in the Beaver Brook watershed. Two rain gages and a temperature gage would be installed in the upper watershed, and a stream gage would be installed downstream of George Street where a stream gage was once maintained by the Corps. Information on rainfall, temperature and streamflow would be relayed to a microcomputer that would monitor conditions and automatically transmit both visual and audible warnings whenever flooding became imminent.

The impacts of your recommended plan, Plan C, upon fish and wildlife resources would not be significantly different from Plan A. Plan B, the nonstructural alternative, has been incorporated into Plan C, but would not contribute to the adverse impacts upon fish and wildlife resources.

Construction activities at both Three Mile Swamp and in Beaver Brook between Marlboro and Water Streets would result in the introduction of suspended and dissolved solids into the downstream area. Although siltation control measures would be implemented to minimize siltation, we would still anticipate significant water quality problems in the event of storms during the construction period.

Channel modification of Beaver Brook in the downtown Keene area would virtually eliminate existing aquatic resources from the 1,750-foot reach during the construction period. We expect that benthic organisms and finfish would repopulate the new stone-lined channel, although at reduced population levels. The new V-shaped channel would maintain a water depth of 1 foot and help retain benthic organisms and provide for fish passage during periods of low streamflow.

Channel construction would also involve the loss of about 0.75 acres of riparian habitat (trees, shrubs and herbaceous vegetation) important to songbirds and small mammals of the area. The planting of flood-tolerant grasses along the upper side slopes would replace a portion of the herbaceous habitat, but would be of limited value to songbirds. Therefore, we recommend that native trees and shrubs be replaced along the streambank in order to mitigate riparian habitat losses.

To facilitate construction and avoid excessive siltation, the dam, discharge channel and earthern dike at Three Mile Swamp would be constructed in the dry. This would entail lowering the existing pond by two vertical feet for a 4-5 month period (April to July or August) and installation of cofferdams to divert streamflows away from the immediate work area.

Lowering the pond per se and installation of cofferdams would temporarily reduce the overall productivity of the wetland, however, upon restoring the water level and removal of the cofferdams productivity should return to normal in one growing season.

Downstream of the dam approximately 200 feet of the existing brook would be replaced by a concrete stilling basin and stone-lined V-shaped discharge channel. Existing aquatic organisms would be eliminated from this area during the construction period. While benthic organisms would repopulate the new channel, and

the V-shape would maintain sufficient water for fish passage, the overall productivity and population diversity within this reach would be lower than under existing conditions. In addition, excavation of the stilling basin and discharge channel would result in the permanent loss of about 0.75 acres of quality riparian and upland forest habitat. As an alternative to clearing and excavating this entire area, we recommend that as much of the area as possible be riprapped with the existing vegetation in place.

We understand that practically all of the material excavated at the dam site and from the channel in the downstream Keene area would be utilized in the construction of the dike on the west side of Three Mile Swamp adjacent to New Hampshire Route 10. Construction of the dike would eliminate all existing shoreline vegetation on the western edge of the wetland for a distance of about 1,100 feet. It would require the removal of 1/2 acre of wetland habitat and about 3/4 acre of upland shrubs and trees. While the loss of 1/2 acre of wetland represents less than 2 percent of the total 30-acre wetland area, the lineal distribution represents about 10 percent of the wetland perimeter. This peripheral habitat, including wetland and upland vegetation, is important to many wildlife species including black ducks, muskrats, small mammals, and a large variety of songbirds. The wetland side of the dike would be faced with stone and the highway side seeded to grass. Neither of these habitat types would make a significant contribution toward mitigating the adverse impacts of peripheral habitat losses. These losses could be avoided by raising Route 10, and we recommend that this be fully investigated as an alternative to the dike.

With the project in operation the modified outlet structure would cause an increase in the magnitude and frequency of flooding in Three Mile Swamp. The extreme case would be during a Standard Project Flood event when the pool level would rise about 4 feet higher than under existing conditions, and would take an extra 24-hour period to drain back to its normal level. The total area inundated would be 120 acres. On a yearly basis, especially during the spring run-off period, the pool would rise about 2 feet higher than under existing conditions. Due to the short duration of flooding, there should be no significant long-term impact upon the area's vegetation. However, the increased frequency and magnitude of flooding could destroy the nests of black ducks and various songbirds, drown the young of muskrats, mink and small mammals, and subject adults to increased predation. Floods occurring in the period from late April to late June would have the most significant adverse impact upon wildlife resources.

We understand that the Three Mile Swamp project would require the taking of about 120 acres of land, approximately 50 acres in fee title and 70 acres in flowage easements. This area could make a significant contribution toward mitigating project induced habitat losses. The possibility of installing a stop log structure in the dam to improve and increase the amount of wetland edge should be investigated. This structure should allow manipulation of water levels about 1 foot above and 1 foot below the normal pool elevation of 787 feet NGVD. In addition, the remaining lands could be managed to increase their wildlife carrying capacity. We recommend that these mitigation measures be fully explored as part of Plan C and be coordinated with the New Hampshire Fish and Game Department and this Service.

We note that the DPR, on pages 87 and 93, credits Plan C (or Plan A) with preservation of the Three Mile Swamp through acquisition of project lands. Yet on page 30 of the DPR it states that "In the absence of a Federal project, the Three Mile Swamp can be expected to remain in its natural state, because of the city's plans for its acquisition and preservation."

Plan B, the nonstructural plan, would have no adverse impacts upon fish and wildlife resources. The Three Mile Swamp area would be preserved without the adverse impacts of Plan C. We cannot support the adverse structural impacts of either Plan A or C. Therefore, from a fish and wildlife viewpoint, we prefer and can support development of Plan B.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor,
New England Field Office

State of New Hampshire
WATER RESOURCES BOARD
37 Pleasant Street
Concord, N.H. 03301
TELEPHONE 271-3406

September 6, 1983

Carl B. Sciple
Colonel, Corps of Engineers
Division Engineer
424 Trapelo Road
Waltham, Mass 02254

Dear Col. Sciple:

This correspondence acknowledges receipt of the "review draft" of the flood damages reduction study of Beaver Brook in Keene, N.H. and can serve as our "letter of intent" to cooperate with the Corps of Engineers and the City of Keene in the execution of this proposal. The Water Resources Board has long been involved in the flood problem associated with Beaver Brook and are encouraged by the progress that has resulted in this proposal. We believe that this project should substantially reduce flood damage in this watershed without high economic and environmental cost.

The Board has sponsored simular projects in the past and will work with all parties to implement this program. We will be in contact with the City of Keene and be available to discuss this project with all concerned following the 30 day comment period.

Respectfully yours,

Delbert F. Downing
Chairman

DFD:VAK:mk
CC: Keene Planning Dept.
C/O Jerry McCullough
Senator Blaisdell

Department of Energy
Chicago Operations Office
Boston Support Office
150 Causeway Street
Boston, MA 02114

SEP 7 1983

Joseph L. Ignazio, Chief
Planning Division
New England Division
Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02254

Dear Mr. Ignazio:

The Boston Support Office of the Dept. of Energy has reviewed the Environmental Assessment of the Flood Damage Reduction Project on Beaver Brook, Keene, New Hampshire.

The only area of concern we can see is a lack of energy related aspects discussed relating to this project.

Thank you for this opportunity to comment.

Sincerely,

Hugh Saussy, Jr.
Director
Boston Support Office

cc: Jerry Nelsen
Assistant Director for
Environmental Protection

OFFICE OF STATE PLANNING
STATE OF NEW HAMPSHIRE
2½ BEACON STREET — CONCORD 03301
TELEPHONE 603-271-2155

September 14, 1983

Mr. David Tomey
Impact Analysis Branch, 113-N
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Tomey:

This is in response to your request for review of "Flood Damage Reduction; Detailed Project Report/Environmental Assessment, Beaver Brook, Keene, New Hampshire; Review Draft dated August 19, 1983."

The Office of State Planning has reviewed the report in terms of its general content, conclusions and floodplain management implications. Although the project is of worthwhile benefit to the City of Keene, we believe the following questions should be given further thought before progress continues. The first issue relates to the recently completed highway improvements to Route 9 and 10 in the vicinity of the proposed flood control structures on Three Mile Swamp. Significant expenditures of public funds have been devoted to realigning both of these roads at their intersection for public safety. The Route 9 crossing of Beaver Brook some 500 yards below the planned outlet structure has resulted in an earthen fill with culverts at its base to accommodate the stream. This substantial fill appears to have the potential of being modified for temporary flood water storage. If such an alternative proved feasible, it could remove the need to construct the outlet structure and related work upstream, thus avoiding those expenses and environmental consequences.

1. Has the USA Corps of Engineers fully evaluated this course of action as to its feasibility from an engineering stand point and in terms of its relative costs?

2. If so, what are the results of this analysis?

A second question has to do with the method of determining the benefit/cost ratios for options A, B, and C:

1. Is it normal procedure to ascribe a 100 year project amortization period to a small project such as the Three Mile Swamp outlet structure?

Thank you for the opportunity to review the draft project report. We look forward to your response.

Very truly yours,

David G. Scott

David G. Scott
Acting Director

DGS:wh/jyb

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF
Planning Division
Plan Formulation Branch

September 27, 1983

Mr. David G. Scott, Acting Director
Office of State Planning
2½ Beacon Street
Concord, New Hampshire 03301

Dear Mr. Scott:

Thank you for your comments on the Draft Detailed Project Report for Flood Damage Reduction, Beaver Brook, Keene, New Hampshire. Your letter, dated September 14, 1983, raises several questions regarding our proposed project which I would like to address.

The first comment concerned the possible use of the State Route 9 highway embankment as an alternate to the Three Mile Swamp outlet structure for temporary floodwater storage. Although initially this would appear to be an attractive alternative to our proposal, the highway embankment would not be suitably designed to retain a temporary pool, and major modifications, including an emergency spillway, would have to be constructed before it could safely serve such a purpose. In addition, to maximize the flood control benefits derived from such a facility, the project should be designed to use all the storage area behind the embankment, and would include the relocation of the N.H. Route 10 highway out of the flood control pool. As you can see, the costs of this alternative go well beyond the scope of our present project, which is limited to a Federal cost of $4 million. In fact, what you suggest is very similar to the Corps' originally proposed Beaver Brook multiple purpose dam, authorized for construction by Congress in 1968. Because of the major costs involved in that project, the Corps was unable to obtain local assurances from the city of Keene, and the project was subsequently deauthorized in 1978. Since that time we have been concentrating on smaller-scale structural and nonstructural measures of flood damage reduction for the city of Keene.

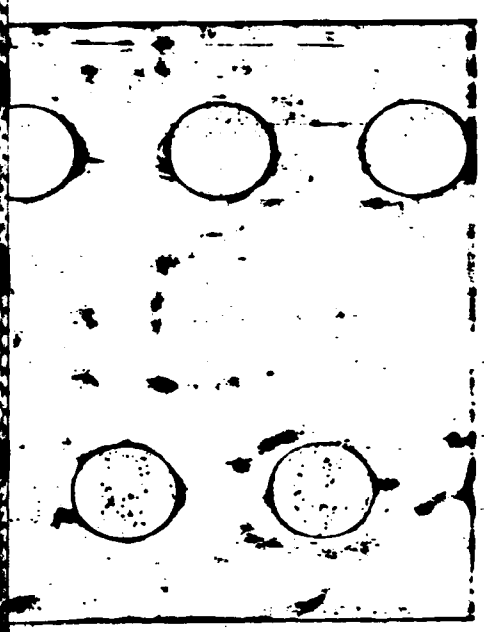
That brings me to your second comment, which concerned the 100-year amortization period ascribed to the proposed project. The period of analysis used for Corps of Engineers projects is established by the number of years over which the project would have significant beneficial or adverse

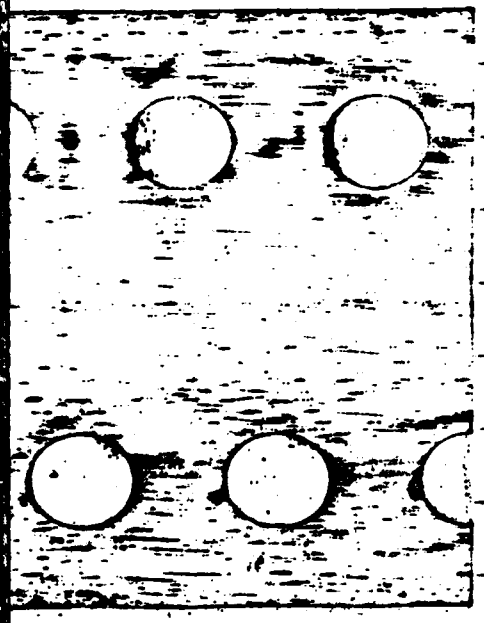
effects, and is limited to a maximum of 100 years. We anticipate that the proposed concrete structure at Three Mile Swamp will provide long-term urban flood protection to the Beaver Brook flood plain and beneficial effects will accrue throughout that period. For this reason we have assigned a 100-year amortization period to this project.

I hope that the above information will address your comments, however, if you have any additional questions, please feel free to call me at (617) 647-8508. Ms. Karen Liska of my staff coordinated our study; she can be reached at (617) 647-8329.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division





September 15 1983
164 Baker St
Keene, N.H 03431

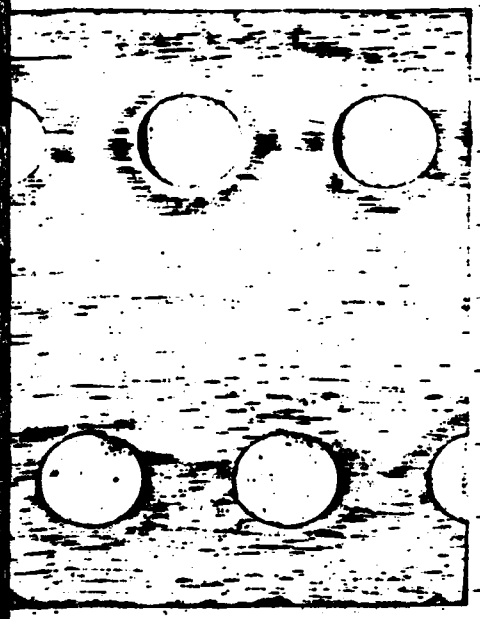
To Whom it may Concern:

These are some of my comments on the proposed Beaver Brook Flood Control Project.

(1) Modification of the outlet at 3 mile Swamp

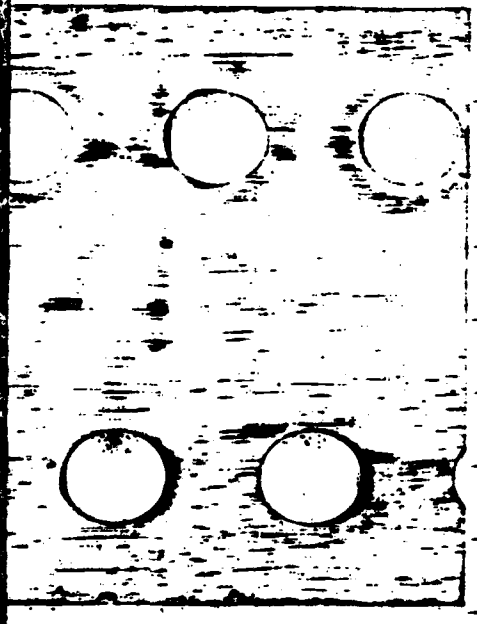
Picture #1 (# on Reverse) was taken from Jct of Rte's 9 + 10 Looking North. State Engineering Drawings of this Location (Station # 72) show the Road Elevation (Rte 10) and the Dam site as both being 752' above Sea level. It also says that the elevation of Rte 10 at this point is 752' above Sea level. I believe that the picture clearly shows that

this information is totally incorrect. The New Rte 10 as shown in this picture is just behind and level with the House at the left. The proposed use of excavated material at the present Dam Site to be used to build an Earthen Berm 2 feet high along Rte 10 to control Flooding is almost totally unnecessary. There is a natural Berm already in Place almost down Rte 10 to where New England Power Lines cross the Road. My conclusion of Phase 1 is that a lot of earth moving and Berm Building is unnecessary. Some thought ought to be given to controling the flow of water where the brook goes under the new Rte 9-10 Intersection.



Cinstruction at Channel Improvement from Water St. to Marlboro St. Photo # 2 taken from across the street from Princess Shoe Co. shows a wide and deep channel but clearly shows the church St Bridge as being restrictive to the efficient flow of water downstream. I measured the church St Bridge as having a opening of 77 square feet. Photo's # 3 + 4 point out the same problem as the Church St. Bridge, namely the restrictive nature of the natural flow of water. This is the Harrison St. Bridge and the end of the previous Channel Work. My measurement of the opening of this Bridge is 120 sq ft. Photo # 5 shows the Water St Bridge Looking North to South. Photo #6 is underneath the

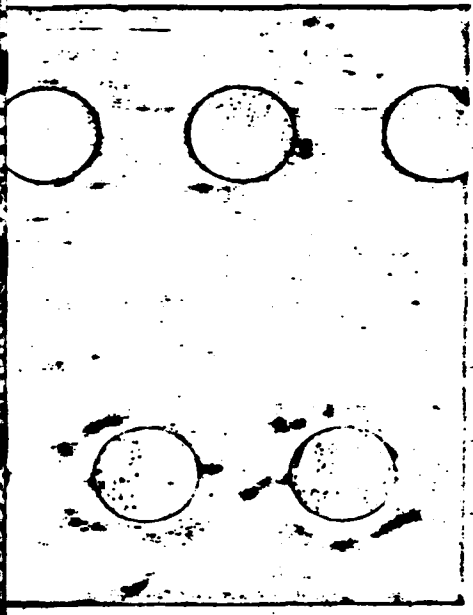
Water St Bridge and shows exposed piping and much brush and other debris. Photo # 7 shows Debris along the west Bank of Beaver Brook by Findings Inc on Water St. The water St Bridge has an opening of 108 sq ft. Photo # 8 shows the upstream side of the Marlboro St Bridge. Near the Entrance to Kingsbury's. Photo # 9 shows the water quality at the same site as Photo # 8, Note the attractive Color! Photo # 10 was taken from the downstream side of the Baker St Bridge. The Marlboro St + Baker St Bridges are almost exact Duplicates of each other and I measure them at 180 sq ft openings.

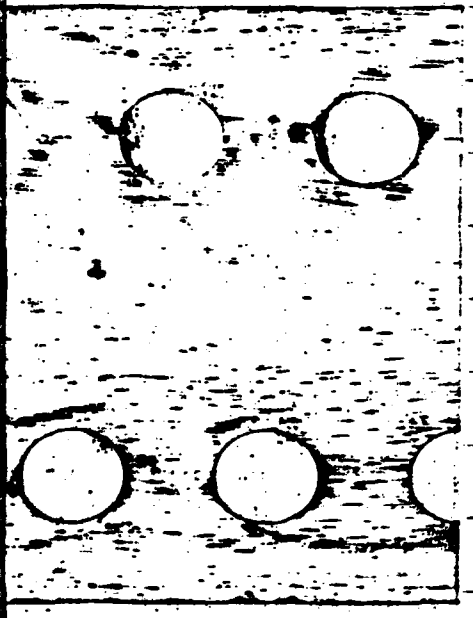


My Comments

Although work on Beaver Brook is needed, channel work alone between Water and Marlboro St will only serve to hold more water. After the channel has filled the water will still flood the general area particularly upstream of Marlboro Street because the water cannot run off because of restrictive bridge openings and downstream water Table at the confluence of Beaver Branch and Ashuelot River. If the object of the Corps of Army Engineers is to create storage capacity of Beaver Brook then the proposal put forth some 3-4 years ago at a Public Hearing In Keene, to build a cement Retaining wall between

Marlboro + Baker Streets should also be considered. The cost of this action could be deducted from what I would consider the unnecessary work of building a complete Earth Berm on Rte 10 to protect it from Flooding. The Bridges at Marlboro and Baker Streets that are held in such low esteem by your draft will carry off more water, than upstream Bridges because of their Larger openings. The above action may well lead to some Flooding in the Large basin between Baker St + Rte 101, but this Basin contains No Housing or Business, and I doubt could seriously endanger Homes on Belmont Ave. I do not wish to end my comment on the downbeat, but





the Hydrophone Line you expect
to locate at Beech Hill State
Forest will be hard to
locate as to the best of any
one's Knowledge No such Forest
exists. Your observations of ice
IN and around Manchester St
have nothing to do with Beal
Brook Flood Plain, but are IN
fluenced by the Branch River
Basin. The Ecological statement
Regarding Trout IN Beaver Bro
is Flawed. Over the past
30 plus years the average stoc
ing of Trout has been abou
3 mile Swamp and the amount
Not usually exceeding 100 fish
Your statement that these fis
Migrate down stream to the
Ashuelot River is just not s
These fish have come downstream

on occasions as far as the city limits. The only way they could go farther would have to be by boat as told to me by the Warden at the now closed Richmond Fish Rearing Station.

Because I live at 164 Baker Street my writing of these comments are self serving. I did attend the Public Hearing held in Keene to discuss this matter, but I noticed by your draft that you had to approach "Keene Businessmen" for their input. Is my concern of any lesser value than Theirs?

Respectfully Yours

Linda Bowman

"Table of Bridge Openings"

Baker St. Bridge

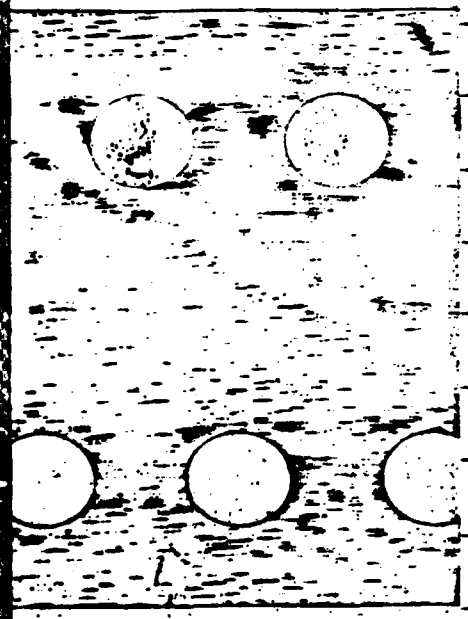
3 openings 7.5' X 8' = 180 Sq. ft.

Marlboro St. Bridge

Same as Baker

Harrison St b/j Princess Shoe

1 opening 6 X 30 = 180 Sq. ft



Church St Bridge

1 opening approx 7 X 11' = 77 Sq. ft

Water St. Bridge

1 opening 6 X 18 = 108 Sq. ft

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION. CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM. MASSACHUSETTS 02254

REPLY TO
ATTENTION OF

Planning Division
Plan Formulation Branch

October 6, 1983

Mr. Paul Bourassa, Jr.
164 Baker Street
Keene, NH 03431

Dear Mr. Bourassa:

Thank you for your comments on the Draft Detailed Project Report for Flood Damage Reduction, Beaver Brook, Keene, New Hampshire. Your letter, dated September 15, 1983, raised a number of questions that I would like to address at this time.

Your first comment concerned the proposed improvements in the vicinity of the Three Mile Swamp, where you specifically questioned the need for a dike to protect the N.H. Route 10 roadway. The survey information that we received from the N.H. Department of Public Works indicates that Station No. 72 of the Route 10 roadway is located adjacent to the existing outlet structure of the Three Mile Swamp, not at the intersection of Routes 9 and 10 as you stated in your letter. Topographic information obtained by the Corps during our study verified that the elevation of Route 10 at this location (Sta. No. 72) is about 792 feet NGVD. During flood periods our project would have a design pool elevation of 797 feet NGVD, which is 5 feet above the roadway. Therefore, there is a need for a dike at this location to prevent flooding of Route 10.

Your second question concerned the proposed channel improvements between Water Street and Marlboro Street. You suggested that the backwater influence of the Ashuelot River and the Branch would negate these improvements. You also expressed your preference for construction of a floodwall between Marlboro Street and Baker Street. The channel improvements that we are proposing are designed to be compatible with the channel improvements constructed by the city in other locations along the Brook, and would increase the channel discharge capacity from about 400 to 600 cubic feet per second. These improvements are directed at relieving flooding during smaller, frequent flood events, and would not significantly improve conditions during larger floods when there would continue to be a backwater influence from the Ashuelot River.

Based on our stage-damage information, however, the proposed improvements are economically feasible and worthy of construction. By comparison, our analysis of low walls and dikes indicated that a dike constructed between Marlboro Street and Baker Street would not be economically feasible. Because each element of a plan must be economically justified, we cannot recommend construction of this dike.

I appreciate your information regarding our erroneous reference to the Beech Hill State Forest; we will delete this reference from the report.

Regarding your statement on the stocking and migration of trout in Beaver Brook, we did not mean to suggest that migration to the Ashuelot River would occur under normal flow conditions. However, it is possible that during spring runoff conditions the discharge of Beaver Brook could encourage some downstream movement. Representatives of the N.H. Fish Game Department have indicated they know of no reason why stocked trout could not have access to the Ashuelot River.

In closing, I would like to thank you again for providing your comments on this proposed project. We appreciate your participation in this project and hope that we have satisfactorily addressed your concerns. If you have any further questions, please feel free to call me at 617-647-8508. Ms. Karen Liska of my staff coordinated our study; she can be reached at 617-647-8329.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

September 29, 1983

Mr. David Tomey
Impact Analysis Branch, 113-N
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Mr. Tomey:

We have reviewed the draft feasability report and the Section 404(b) evaluation and environmental assessment for the proposed Beaver Brook Flood Damage Reduction Project in Keene, New Hampshire.

We agree that this project should provide several important public benefits and we have no objection to the overall proposal. However, the final document should examine the feasability of raising Route 10 to a sufficient height as to obviate the need for construction of a separate dike in the wetland area. If practicable, this alternative would preserve approximately one half acre of valuable wetland habitat. As you know, Section 230.10(a) requires that the least environmentally damaging practicable alternative be implemented (we note that §230.10 was omitted from your 404(b) evaluation).

Please keep us informed on this project. Questions regarding this letter should be directed to Scott Carroll at FTS 223-5061.

Sincerely,

for Clyde F. Shufelt, Chief
Municipal Permits Branch

cc: US F&WS, Concord, NH

BOSTON AND MAINE CORPORATION
IRON HORSE PARK
NORTH BILLERICA, MA 01862-
(617) 663-9300

September 13, 1983

Mr. David Tomey
Impact Analysis Branch, 113-N
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Re: Flood Damage Reduction Project
Beaver Brook
Keene, N. H.

Dear Mr. Tomey:

We have received the Public Notice and Draft Detailed Project Report for the Beaver Brook Flood Damage Reduction Study. Our preliminary review indicates that the railroad will be involved with the review, approval, and inspection of the channel improvements proposed between station 13+50 and 14+50. These improvements will affect our bridge structure number 90.83 on the Cheshire Branch.

Attached please find our standard information package explaining our railroad policies and procedures for your use in preparation of the plans and specifications. Upon completion of the construction plans and specifications. Please send five (5) sets each for our review and approval.

Please note that we require advance deposits to cover all costs incured the railroad. Appropriate funding sources should be established to handle this requirement.

If you have any further questions regarding our requirements please contact me at 663-6972.

Very truly yours,

Gary A. Gordon

Gary A. Gordon, P. E.
Engineer of Design

GAG/bas

# STATE OF NEW HAMPSHIRE

## DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

JOHN O. MORTON BUILDING CONCORD, N.H. 03301

JOHN A. CLEMENTS, P.E.
COMMISSIONER

REPLY ADDRESS:
MAINTENANCE DIVISION SEVEN
POST OFFICE BOX 643
KEENE, N.H. 03431
Phone: 603-352-2302

Sept. 22, 1983

Mr. David Tomey
Impact Analysis Branch, 113-N
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

Subject: Draft Project Report for Beaver Brook Flood Damage Reduction Study in Keene, N. H.

Dear Sir:

Having reviewed the Review Draft, I would Make the following comments. I should note; however, that my comments are confined to N.H. Route 10 north, adjacent to three mile swamp, as this is the only area of concern to me at this time.

Note: N.H. Route 10 was reconstructed in 1979. The Right of Way in this area (see enclosed plan) is approximately one hundred (100') from center of Route 10. The pavement and shoulders are in excellent condition.

My areas of concern are as follows:

1. The condition of the pavement and shoulders during construction be protected toavoid any damage whatsoever.
2. Any disturbed areas within our R.O.W. be treated as required under normal construction practices. (Per N.H. Standard Specifications for Road and Bridge Construction as approved and adppted in 1983).
3. Construction of any new culverts under N.H. Route 10 may have to be jacked to avoid disturbing the existing pavement.
4. The use of "off road" type construction vehicles (over-width or over-weight) on N.H. Route 10 will not be allowed.
5. Disturbance to traffic on N. H. Route 10 be kept to a minimum.

Very truly yours,

R. N. Dodge, P.E.
Division Engineer

Enc.
Copy: L. Kenison
John L. Oudens

The State of New Hampshire

COMMISSIONERS

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BRUCE A. HOMER, P.E., Vice Chairman
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STAFF

WILLIAM A. HEALY, P.E.
Executive Director

DANIEL COLLINS, P.E.
Deputy Executive Director
Chief Engineer

Water Supply and Pollution Control Commission
Hazen Drive — P.O. Box 95
Concord, N.H. 03301

October 20, 1983

Mr. Joseph L. Ignazio, Chief
Planning Division
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Subject: Flood Damage Reduction Study, Beaver Brook, Keene, N.H.

Dear Mr. Ignazio:

The subject report has been reviewed by this office.

This will certify that on review of the subject request, the Commission has determined that the project described in the request will be in conformance with applicable New Hampshire laws; and that, to the best of its knowledge, no Federal limitation applicable to the proposed project has been established under Section 301(b), 302, 306 or 307 of the Federal Water Pollution Control Act (P.L. 92-500), as amended to date.

This certification is furnished pursuant to Sections 401(a)(1) and 401(d) of the Act.

Very truly yours,

Peter H. Allen

PHA/mb

cc: Mr. Delbert Downing
N. H. Wetlands Board

# CITY OF KEENE

NEW HAMPSHIRE 03431

January 27, 1984

Carl B. Sciple, Colonel
Army Corps pf Engineers
Department of the Army
424 Trapelo Road
Waltham, MA 02254

Dear Col. Sciple:

Please find enclosed herewith a copy of a Finance Committee report that the City Council adopted on January 19, 1984. In accordance with that City Council action, please consider this to be a letter of intent by the City supporting the pursuance of the Beaver Brook Project further by the Corps. The Council understands that this is a non-binding letter of intent but you should know that the vote of the Council to pursue the project was 13 - 2.

I would like to thank in particular, Karen Liska of your staff, for the effort she made to properly explain the project to the City Council. Her efforts contributed greatly to the Council's change in position in this matter.

If you need further information, please contact me.

Sincerely,

Patrick MacQueen
City Manager

/ehl

Enc.

cc: Jerry F. McCollough, Planning Director
Pamela M. Bower, Planning Assistant

6A17

City of Keene
New Hampshire

January 17, 1984

TO: Honorable Mayor and City Council

FROM: Finance Committee

SUBJECT: COUNCIL REFERRAL - Beaver Brook Project

On a vote of 4-1 the Committee recommends that the Manager be authorized to write a non-binding letter of intent by the City supporting the Corps pursuing the flood recommendation further.

In City Council January 19, 1984.
Voted to carry out the intent of the report.

Patricia A. Little
City Clerk

Chairman/Designee

Background Notes:

Councilor Donegan stated that he had been contacted by someone who felt that there should be additional public hearings on this matter and that perhaps the proposed dams should be discussed as a separate issue since that was the major point of controversy. Jerry McCollough explained that if the Beaver Brook project process were continued, there would be additional public hearings along the way as the plan got more specific. Chris Tasoulas addressed the Committee and stated that he had lived in the area all his life and had seen the damage that flooding along Beaver Brook could do. He said at one time there was a dam at Three-Mile Swamp but the hurricane of 1938 wiped it out. He said he felt that this was an extremely important issue and that since the Council was not asked to be making a binding decision now, that there was really no reason not to proceed further to keep the idea of the project alive. Sue Thielen stated that she was not for or against the project but was concerned about any impact it might have below Marlboro Street. Jerry McCollough again reviewed the map showing significant areas that would not be flooded in a ten-year storm as a result of the project. He said overall the flooding in this type of a storm would be reduced by about 1-1/2 feet mostly because the retardation effect of the spillway.

# COMMENTS AND RESPONSES

The following comments are taken from letters received during the 30-day review of the Draft Detailed Project Report and Environmental Assessment.

FEDERAL AGENCIES

U.S. Fish and Wildlife Service

Comment 1: "Channel construction would also involve the loss of about 0.75 acres of riparian habitat (trees, shrubs, and heraceous vegetation) important to songbirds and small mammals of the area. The planting of the flood-tolerant grasses along the upper side slopes would replace a portion of the herbaceous habitat, but would be of limited value to songbirds. Therefore we recommend that native trees and shrubs be replaced along the streambank in order to mitigate riparian habitat losses."

Response: The hydraulic improvements proposed for the Beaver Brook channel between Marlboro Street and Water Street have been designed to maximize improved flow characteristics while retaining an economically justified project. This has resulted in the employment of the least expensive construction method that is acceptable in this location, and currently the ratio of benefits to costs for the channel is 1.0 to 1. However, the project economics can accomodate the expenditure of approximately $1,000 to replace native trees and brush along the top of the bank, to mitigate the loss of this habitat. As an added measure, our construction plans and specifications will include provisions to preserve mature trees within the construction area which do not lie within the limits of the new channel.

Comment 2: "Excavation of the stilling basin and discharge channel would result in permanent loss of about 0.75 acres of quality riparian and upland forest habitat. As an alternative to clearing and excavating this entire area, we recommend that as much of the area as possible be riprapped with existing vegetation in place."

Response: The design of the stilling basin and discharge channel is based on the velocities and depth of flows being discharged over the spillway during a Standard Project Flood. These velocities will be about 9 feet per second, and would disturb any vegetation remaining in the area, causing debris problems at downstream culverts. In addition, if riprap was placed around existing vegetation it would not provide a uniform blanket of protection against erosion in the discharge channel.

Comment 3: "The wetland side of the dike would be faced with stone and the highway side seeded with grass. Neither of these habitat types would make a significant contribution toward mitigating the adverse impacts of peripheral habitat losses. These losses could be avoided by raising Route 10, and we recommend that this be fully investigated as an alternative to the dike."

Response: In the initial design of the proposed project the raising of the Route 10 highway was considered as an alterantive to constructing the dike. However, because the road surface would have to be raised as much as 5 feet in one location, the actual reconstruction would extend over a much greater distance than 1100 linear feet of impact area, simply to provide an acceptable grade up to the design roadway elevation. As a result, the reconstruction of Route 10 would be much more expensive than the construction of the dike. Because under the Section 205 authority the non-Federal sponsor would have to pay for this "relocation", and because the highway was recently reconstructed by the State, the alternative of raising Route 10 was considered impractical and unacceptable, and was dropped from further consideration. However, as an alternative mitigation measure, the Corps of Engineers would consider raising the permanent pool elevation of the wetland, if this was found to be acceptable, so as to increase the available peripheral habitat around the wetland. This issue will be addressed further during the preparation of plans and specifications.

Comment 4: "The possibility of installing a stop log structure in the dam to improve and increase the amount of wetland edge should be investigated. This structure should allow manipulation of water levels about 1 foot above and 1 foot below the normal pool elevation of 787 ft. NGVD. In addition, the remaining lands could be managed to increase their wildlife carrying capacity. We recommend that mitigation measures be fully explored ..."

Response: Currently the project plans include a stop-log structure to facilitate varying the pool level between elevations 781 and 787 feet NGVD. As stated in the above response, the extension of this structure up to elevation 788 feet NGVD will be addressed during the preparation of plans and specifications. With respect to the management of project lands to increase their wildlife carrying capacity, this responsibility would traditionally rest with the non-Federal sponsor under the Section 205 authority. However, in a telephone conversation with the New Hampshire Fish and Game Department on 10 November 1983, the State expressed no interest in managing project lands for wildlife purposes.

Comment 5: "We note that the DPR on pages 87 and 93 credits Plan C (or Plan A) with preservation of the Three Mile Swamp through acquisition of project lands. Yet on page 30 of the DPR it states that "In the absense of a Federal project, the Three Mile Swamp can be expected to remain in its natural state, because of the city's plans for its acquisiton and preservation."

Response: The statement on page 30 was revised prior to the public release of the Draft DPR, to more accurately reflect the future stability of Three Mile Swamp. In fact the protection of the swamp in the without project condition would be completely dependent upon the zoning laws of the city of Keene, as the city actually did not plan to acquire the land by its own means.

Comment 6: "Plan B, the nonstructural plan, would have no adverse impacts upon fish and wildlife resources. The Three Mile Swamp area would be preserved without adverse impacts of Plan C. We cannot support the adverse structural impacts of either Plan A or C. Therefore, from a fish and wildlife viewpoint, we prefer and can support development of Plan B."

Response: Thank you for your review of this project under the Fish and Wildlife Coordination Act and we acknowledge your opinion.

U.S. Department of Energy

Comment: "The only area of concern we can see is a lack of energy related aspects discussed relating to this project."

Response: We do not consider the Three Mile Swamp outlet structure to be a suitable location for hydroelectric generating facilities because the head under normal flow conditions is limited to about 8 feet and the contributing drainage area is only 6 square miles.

U.S. Environmental Protection Agency

Comment 1: "The final document should examine the feasibility of raising Route 10 to a sufficient height as to obviate the need for construction of a separate dike in the wetland area. If practicable, this alterantive would preserve approximately one-half acre of valuable wetland habitat.

Response: See response to similar comment posed by the U.S. Fish and Wildlife Service.

Comment 2: "We note that Section 230.10 was omitted from your 404(b) evaluation."

Response: The considerations in 230.10 are addressed in the Findings of Compliance.

STATE AGENCIES

Office of State Planning

Comments were addressed by COE letter dated 27 September 1983.

Department of Public Works and Highways

Comments by the DPW on the construction of the dike will be addressed during the preparation of construction plans and specifications.

PRIVATE COMPANIES AND CITIZENS

Boston and Maine Corporation

Cpmments on the specific design of channel improvements will be addressed during the preparation of construction plans and specifications.

Mr. Paul Bourassa, Jr.

Comments were addressed by COE letter dated 6 October 1983.